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# USSR Report

MATERIALS SCIENCE AND METALLURGY

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16 October 1985

## USSR REPORT

### MATERIALS SCIENCE AND METALLURGY

#### CONTENTS

##### ALUMINUM AND ITS ALLOYS

Specifics of Interaction of Boron With Liquid Aluminum (S. O. Gevlich, M. I. Tylkina, et al.; METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV, No 8, Aug 84).....	1
Segregation of Alloying Elements at Interface Between Aluminum Melt and Carbon Fiber (A. K. Zaytsev, D. K. Belashchenko, et al.; POVERKHNOST: FIZIKA, KHIMIYA, MEKHANIKA, No 6, Jun 85).....	1
Aluminum Powder Alloys for Production of Sintered Materials (Review) (V. G. Gopiyenko, Val. G. Gopiyenko, et al., POROSHKOVAYA METALLURGIYA, No 4, Apr 85).....	2
Study of Certain Properties of Alloys of Tantalum-Aluminum Oxides (A. M. Avetisyan; IZVESTIYA AKADEMII NAUK ARMYANSKOY SSR: SERIYA TEKHNICHESKIKH NAUK, No 2, Mar-Apr 85).....	3
Perfecting Technology for Continuous Casting of Aluminum Alloy Ingots (A. I. Zhernov; TSVETNYYE METALLY, No 6, Jun 85).....	4
Predicting Properties of Cast Aluminum Alloys, Depending on Their Chemical Composition (A. A. Offengenden, Yu. Ye. Kupershtok, et al.; TSVETNYYE METALLY, No 5, May 85).....	4
Modifying Aluminum Alloys With Titanium (V. I. Nikitin, G. V. Cherepok, et al.; TSVETNYYE METALLY, No 5, May 85).....	5
Use of Recycled Aluminum Alloy With Increased Zinc Content (N. A. Balanayeva, Yu. B. Bychkov, et al.; TSVETNYYE METALLY, No 6, Jun 85).....	5

Broader Use of Aluminum Alloys Made of Recycled Raw Materials for Making Shaped Semifinished Products (V. G. Badayev, N. Yu. Eyduk; TSVETNYYE METALLY, No 6, Jun 85).....	6
--	---

AMORPHOUS METALS

Structural Relaxation and Crystallization of Amorphous Alloy $Ni_{77}P_{23}$ (V. P. Naberezhnykh, T. T. Moroz, et al.; IZVESTIYA AKADEMII NAUK SSSR: METALLY, No 3, May-Jun 85).....	7
---	---

Evaluation of Conditions for Preserving Amorphous Structure of Materials During Detonation Compacting (V. F. Nesterenko, A. V. Muzykantov; FIZIKA GORENIYA I VZRYVA, No 2, Mar-Apr 85).....	7
--	---

ANALYSIS AND TESTING

Methods for Producing R Curves and Their Use for Evaluation of Material (A Review) (G. S. Neshpor, G. D. Kudryavtseva, et al.; ZAVODSKAYA LABORATORIYA, No 1, Jan 85).....	9
---	---

Influence of Beam Divergence on Accuracy of Experimental- Analytic Determination of Analyzed Layer Thickness in Slipping-Beam X-Ray Studies of Objects (O. K. Kolerov, A. N. Logvinov, et al.; ZAVODSKAYA LABORATORIYA, No 1, Jan 85).....	9
--	---

COATINGS

Structure and Properties of Spray-Coated Materials Based on Aluminum Oxide (V. K. Pivovarov, B. M. Mashkov, et al.; VESTSI AKADEMII NAUK BSSR, No 1, Jan-Mar 85).....	10
--	----

Cathode-Anode Device for Hardening of Parts by Electrolytic Boriding (V. Ya. Chel'tsov, V. B. Raytses, et al.; TEKHNOLOGIYA I ORGANIZATSIYA PROIZVODSTVA, No 4, Oct-Dec 84). 10	10
--	----

Electrical and Magnetic Properties of Amorphous Coatings of Alloy $Fe_5Co_{79}Mo_2B_{14}$ (M. A. Parfenenok, I. I. Rosik, et al.; FIZIKA METALLOV I METALLOVEDENIYE, No 2, Feb 85).....	11
--	----

## COMPOSITE MATERIALS

- Eight-Bladed Composite-Material Propeller Tested on AN-32 Plane  
(V. Belikov; IZVESTIYA, 12 Jul 85)..... 12
- Kinetics of Conductance Changes Due to Diffusional Interaction  
of Components in Three-Dimensional Fiber-Reinforced  
Composite Materials  
(Yu. P. Zarichnyak, A. B. Utkin; POROSHKOVAYA  
METALLURGIYA, No 4, Apr 85)..... 13
- Formation of Composite Boride Coatings by Low-Temperature  
Annealing of Electrolytic Deposit  
(Yu. A. Gusliyenko, I. M. Fedorchenko, et al.;  
POROSHKOVAYA METALLURGIYA, No 4, Apr 85)..... 14
- Kinetics of Spontaneous Crystallization of Cubic Boron Nitride  
(V. B. Shipilo, V. V. Sergeyev; POROSHKOVAYA  
METALLURGIYA, No 4, Apr 85)..... 14

## CORROSION

- Corrosion Resistance and Corrosion-Thermal Fatigue of Chromium-  
Plated Pipes  
(A. A. Ots, Y. P. Layd, et al.; TEPLOENERGETIKA, No 4,  
Apr 85)..... 16

## ENERGY EFFECTS

- Patterns of Multi-Pulse Laser Radiation Action on Metal Targets  
(O. I. Kalabushkin, L. N. Kaporskiy, et al.; IZVESTIYA  
AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA, No 6, Jun 85)..... 17
- Features of Heating Metals With Intensive Radiation in  
Oxidizing Medium  
(V. V. Bazhenov, A. M. Bonch-Bruyevich, et al.; IZVESTIYA  
AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA, No 6, Jun 85)..... 17
- Surface Destruction of Cu and Mo-Mirrors by Powerful  
Coherent Irradiation  
(V. P. Aksenov, B. G. Zhurkin; IZVESTIYA AKADEMII NAUK  
SSSR: SERIYA FIZICHESKAYA, No 6, Jun 85)..... 18

## FORMING

- Sheet Stamping of Parts With Heating by Flameless Gas  
Infrared Burners  
(V. I. Zav'yalova, N. M. Martynova; KUZNECHNO-  
SHTAMPOVOCHNOYE PROIZVODSTVO, No 12, Dec 84)..... 19

## FOUNDRY

- Physical Simulation of Conductive-Stirring Process in  
Unsolidified Molten Part of Ingot  
(V. M. Fedotov, V. D. Suboch, et al.; MAGNITNAYA  
GIDRODINAMIKA, No 4, Oct-Dec 84)..... 20

## GLASS AND CERAMICS

- Use of Nickel Production Slag for Producing Glass Crystal Materials  
(L. P. Kruchinina, L. P. Koshkina; TSVETNYYE METALLY,  
No 6, Jun 85)..... 21

## HEAT TREATMENT

- Thermal Physics of Plasma Processing of Finely Dispersed Particles  
(A. A. Uglov, Ye. M. Ivanov; FIZIKA I KHIMIYA OBRABOTKI  
MATERIALOV, No 2, Mar-Apr 85)..... 22

- Oxidation of Metal Particles in Initial Heating Zone During  
Combustion of SVS [Samorasprostranyayushchiysy  
Vysokotemperaturnyy Sintez (Self-Propagating High-Temperature  
Synthesis)] System  
(V. N. Bloshenko, V. A. Boki, et al.; FIZIKA GORENIYA I  
VZRYVA, No 1, Jan-Feb 85)..... 22

- Effect of Thermal Processing of Fine Structure and Failure  
Mechanism of Plasma-Applied Aluminum Alloys  
(V. V. Rybin, A. A. Alipova, et al.; IZVESTIYA AKADEMII  
NAUK SSSR: METALLY, No 3, May-Jun 85)..... 23

- Effect of Design, Hydromechanical and Temperature Factors on  
Intensity of Accelerated Cooling During Thermomechanical  
Processing of Light-Section Metals  
(V. T. Zhadan, Yu. A. Samoylovich, et al.; IZVESTIYA  
AKADEMII NAUK SSSR: METALLY, No 3, May-Jun 85)..... 23

## INSTRUMENTATION AND EQUIPMENT

- Portable Electric Welding Unit  
(I. Demchenko; SOTSIALISTICHESKAYA INDUSTRIYA, 20 Jun 85).... 25

- Physics Institute Develops Metal-Inspection Instruments  
(G. Novikov; SOTSIALISTICHESKAYA INDUSTRIYA, 25 Jun 85)..... 25

- Three-Phase Plasma Heating Devices and Prospects for Their Use.  
Report I  
(B. Ye. Paton, Yu. V. Latash, et al.; PROBLEMY  
SPETSIAL'NOY ELEKTROMETALLURGII, No 1, Jan-Mar 85)..... 26

## NONFERROUS METALLURGY

- Uzbek Science Academy President Visits Troubled Almalyk  
(T. Rashidov; PRAVDA VOSTOKA, 19 Mar 85)..... 27
- Features of Structurally Stressed State of Phases in Refractory  
Nickel Alloys  
(A. I. Samoylov, I. A. Ignatova, et al.; IZVESTIYA  
AKADEMII NAUK SSSR: METALLY, No 6, Nov-Dec 84)..... 28
- Study of Recrystallization of Refractory Nickel Alloy  
(V. F. Sukhovarov, Ye. A. Pecherkin, et al.; IZVESTIYA  
AKADEMII NAUK SSSR: METALLY, No 6, Nov-Dec 84)..... 28
- Thermodynamic Analysis of Cerium-Induced Reduction of Nickel  
Alloys  
(V. V. Pokrovskiy, Ye. L. Gyulikhandanov, et al.;  
IZVESTIYA AKADEMII NAUK SSSR: METALLY, No 5, Sep-Oct 84)..... 29
- Lomako Review Problems in Nonferrous Metallurgy  
(P. Lomako; IZVESTIYA, 9 Jun 85)..... 30

## PHYSICAL PROPERTIES

- Change in Reflective Capacity and Thermal Durability of Metal  
Alloys During Selective Oxidation  
(A. P. Gagarin, V. G. Dorofeyev, et al.; IZVESTIYA  
AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA, No 6, Jun 85)..... 34

## POWDER METALLURGY

- Study of Effects of Ionizing Irradiation on Nitriding of Metals  
(O. K. Fomin, V. A. Chevychelov; KHIMIYA VYSOKIKH  
ENERGIY, No 1, Jan-Feb 85)..... 35
- Heat Conductivity of Certain Self-Propagating High-Temperature  
Synthesis Systems Based on Aluminum  
(V. V. Aleksandrov, V. A. Grudzev, et al.; FIZIKA GORENIYA  
I VZRYVA, No 1, Jan-Feb 85)..... 35
- Optimization of Comminution Process in Industrial Production of  
Powder From Steel Chips  
(V. L. Esikman, S. S. Kiparisov, et al.; POROSHKOVAYA  
METALLURGIYA, No 4, Apr 85)..... 36

## RARE METALS

- Activation of Mechanical Deformation of Alloy Zr + 2.5% Nb With  
Accelerated Electrons and Electrical Current  
(M. M. Moiseyenko, O. A. Troitskiy, et al.; IZVESTIYA  
AKADEMII NAUK SSSR: METALLY, No 1, Jan-Feb 85)..... 37

Nature of Splitting Failure of Molybdenum, Nickel and Titanium (V. K. Golubev, S. A. Novikov, et al.; PROBLEMY PROCHNOSTI, No 4, Apr 85).....	37
Changes in Properties of Niobium Alloys After Exposure to Lithium (G. G. Maksimovich, M. I. Ignativ; FIZIKO- KHIMICHESKAYA MEKHANIKA MATERIALOV, No 2, Mar-Apr 85).....	38

SINGLE CRYSTALS

Bond of Elasticity Extreme and Physical Characteristics of Thread-Like Monocrystals (O. D. Kanchev; IZVESTIYA AKADEMII NAUK SSSR: METALLY, No 3, May-Jun 85).....	39
--	----

STEEL

Technology for Making High-Speed Steels Without Costly Alloys (NTR: PROBLEMY I RESHENIYA, 28 May-10 Jun 85).....	40
Improvement of Control of Development of Specialized Electrometallurgy (I. N. Ivanov, N. I. Astakhova, et al.; PROBLEMY SPETSIAL'NOY ELEKTROMETALLURGII, No 1, Jan-Mar 85).....	41
Suppressing Crack Growth During Detonation Strain Hardening of Metals (R. P. Didyk, L. V. Gryaznova; FIZIKA I KHIMIYA OBRABOTKI MATERIALOV, No 2, Mar-Apr 83).....	41
Fatigue Striation Step and Crack Growth Rate (N. M. Grinberg; FIZIKO-KHIMICHESKAYA MEKHANIKA MATERIALOV, No 2, Mar-Apr 85).....	42
Design of Steel Struts With Uniform or Stepwise Varying Cross Section for Stability Within Elastoplastic Range Under Arbitrary Load (M. Kh. Mullagulov; PROBLEMY PROCHNOSTI, No 9, Sep 84).....	42
Plasma-Mechanical Working of Difficult-To-Work Steels (S. A. Mikhal'kova, A.V. Solod; TEKHOLOGIYA I ORGANIZATSIYA PROIZVODSTVA, No 4, Oct-Dec 84).....	43
Steel Industry Ministry Neglects Rolling-Drawing Process (Ye. Tkachenko; SOTSIALISTICHESKAYA INDUSTRIYA, 9 Jul 85)....	44
Promising Bearing Materials (K. P. Zimina; AVTOMOBIL'NAYA PROMYSHLENNOST', No 5, Mar 85).	46
Surface Oxidation of Steel During Laser Irradiation (S. I. Gubenko; IZVESTIYA AKADEMII NAUK SSSR: METALLY, No 3, May-Jun 85).....	46



## TITANIUM

Self-Purification of CBC Titanium Carbide From Impurity Oxygen (V. N. Bloshenko, V. A. Bokyy, et al.; FIZIKA GORENIYA I VZRYVA, No 6, Nov-Dec 84).....	48
Dissolution of Metal Oxide Film in the Process of Synthesis of Titanium Carbide (V. N. Bloshenko, V. A. Bokyy, et al.; FIZIKA GORENIYA I VZRYVA, No 6, Nov-Dec 84).....	48
Technology of Production of Semifinished Goods From Titanium Nickelide Based Alloys With Shape Memory Effect (N. F. Anoshkin, G. A. Bochvar, et al.; TSVETNYYE METALLY, No 2, Feb 85).....	49
Absorption and Diffusion of Hydrogen in Metals and Alloys Upon Electrochemical Treatment (Yu. A. Belobragin; ELEKTRONNAYA OBRABOTKA MATERIALOV, No 4, Jul-Aug 84).....	49
Tribotechnical Features of Electric Spark Coatings Based on Titanium Diboride (V. V. Polotay, A. D. Verkhoturov, et al.; POROSHKOVAYA METALLURGIYA, No 5, May 85).....	50
Buffering Properties of Porous Titanium and Pseudoalloys Based on It (L. I. Tuchinskiy, V. G. Sharapov, et al.; POROSHKOVAYA METALLURGIYA, No 5, May 85).....	50
Evaluation of Quality of Titanium Tetrachloride (Ye. A. Cherepanova, L. M. Gurevich, et al.; TSVETNYYE METALLY, No 6, Jun 85).....	51

## TRANSFORMATION AND STRUCTURE

Role of Optimization of Heterogeneity in Preparing Ultra-Fine-Grained Structure of Superplastic Alloys (V. K. Portnoy; IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: TSVETNAYA METALLURGIYA, No 1, Jan-Feb 85).....	52
Stability of Two Fibers in an Elastic Matrix at Slight Deformations (S. D. Akbarov, A. N. Guz'; PRIKLADNAYA MEKHANIKA, No 1, Jan 85).....	52
Determination of Elastic Properties of Porous Material (B. T. Golovchan, V. I. Kush; DOKLADY AKADEMII NAUK UKRAINSKOY SSR. SERIYA A. FIZIKO-MATEMATICHESKIYE I TEKNICHESKIYE NAUKI, No 1, Jan 85).....	53

Projection of Solidus Surface and Reaction Upon Crystallization of Ru-ZrRu-ZrIr-Ir System Alloys (V. N. Yerenko, V. G. Khoruzhaya, et al.; DOKLADY AKADEMII NAUK UKRAINSKOY SSR. SERIYA A. FIZIKO-MATEMATICHESKIYE I TEKHNICHESKIYE NAUKI, No 1, Jan 85).....	54
Regularities of Structure Formation Upon Graphitization of Mixed Alloys (I. O. Semenova, V. I. Movchan; IZVESTIYA VYSSHIKH UCHEBNIKH ZAVEDENIY: CHERNAYA METALLURGIYA, No 1, Jan 85)....	54
Phase Transitions and Features of Physical Properties in System of Non-Isostructural Sodium-Lithium-Cadmium Niobates (Ye. G. Fesenko, L. A. Reznichenko, et al.; ZHURNAL TEKHNICHESKOY FIZIKI, No 3, Mar 85).....	55
Thermomagnetic Analysis of Processes Leading to High Coercivity State of Alloys $Sm(Co,Cu)_6$ and $Sm(Co,Cu,Fe,Zr)_{7.4}$ (V. I. Khrabrov, Ya. S. Shur, et al.; FIZIKA METALLOV I METALLOVEDENIYE, No 1, Jan 85).....	55
Dependence of Fatigue Striation Step on Range of Coefficient of Stress Intensity (L. R. Botvina, L. V. Limar'; FIZIKO-KHIMICHESKAYA MEKHANIKA MATERIALOV, No 2, Mar-Apr 85).....	56
Homogenization of Alloys of Multicomponent System Under Weightless Conditions (Yu. M. Gel'fgat, L. A. Gorbunov; IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA, No 4, Apr 85).....	57
Specifics of High Pressure on $\alpha\gamma$ Transformation in Fe-Ni-Co-Ti Alloy (L. P. Gun'ko, V. M. Yermakov, et al.; FIZIKA METALLOV I METALLOVEDENIYE, No 6, Dec 84).....	57
Structure and Properties of Porous $Ni-Al_2O_3$ Vacuum Condensates (B. A. Movchan, N. I. Grechanyuk, et al.; FIZIKA I KHIMIYA OBRABOTKI MATERIALOV, No 6, Nov-Dec 84).....	58
Possible Disruption of Invariance of Kinetic Fatigue Fracture Diagrams Caused by Crack Closure (O. N. Romaniv, A. N. Tkach, et al.; FIZIKO-KHIMICHESKAYA MEKHANIKA MATERIALOV, No 6, Nov-Dec 84).....	58
Nature of Strength of Metals and Cermets (G. I. Kuz'menko, A. I. Nikiforov; PROBLEMY PROCHNOSTI, No 9, Sep 84).....	59

Effect of Ultra-Highspeed Crystallization on Structure of Ni-Ti-Si and Ni-Ti-Cu Alloys (M. I. Zakharova, A. F. Khundzhua, et al.; IZVESTIYA AKADEMII NAUK SSSR: METALLY, No 5, Sep-Oct 84).....	60
Diffusional Permeability of Interface Boundaries in Eutectic Alloy Melt-Grown by Method of Oriented Crystallization (S. Z. Bokshteyn, L. V. Vasilenok, et al.; DOKLADY AKADEMII NAUK SSSR: No 3, Jan 85).....	60
Structural Phase Conversions and Properties of the Alloys NiTi and NiTiFe (V. G. Pushin, V. N. Khachin, et al.; DOKLADY AKADEMII NAUK SSSR, No 6, Aug 84).....	61
Structure and Ductility of Iron-Carbon Eutectic Alloys (P. F. Nizhnikovskaya; METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV, No 9, Sep 84).....	61
Crystallization and Primary Structure of Fe-C-Al-Alloys (A. I. Yatsenko, N. I. Repina, et al.; METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV, No 9, Sep 84).....	62
Formation of Eutectic Structures in Binary Metal System Alloys (P. A. Parkhutik; VESTSI AKADEMII NAUK BSSR, No 1, Jan-Mar 85).....	62
Anomalous Extrusion of Metals in Ultrathin Channels (V. N. Bogomolov, V. V. Zhuravlev, et al.; PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI, No 6, 26 Mar 85).....	63
Phase Composition and Structural Specifics of Vacuum Hafnium Dioxide Condensates (G. I. Batalin, A. V. Kachur, et al.; DOKLADY AKADEMII NAUK UKRAINSKOY SSR. SERIYA A. FIZIKO-MATEMATICHESKIYE I TEKHNIЧЕСКИYE NAUKI, No 3, Mar 85 .....	63
Vitreous Structures in Metal Alloys Irradiated by High-Energy Beams (A. I. Ilin, V. S. Kraposhin; POVERKHNOST: FIZIKA, KHIMIYA, MEKHANIKA, No 6, Jun 85).....	64
Formation of Periodic Structures on Oxidizing Metals Under Impact of Coherent Light (V. V. Bazhenov, V. S. Makin, et al.; IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA, No 6, Jun 85).....	65
WELDING	
Welding of Austenitic Steels Irradiated by Neutrons in Nuclear Reactor (Ye. A. Krylov; SVAROCHNOYE PROIZVODSTVO, No 5, May 85).....	66

Increasing Stability of Arc and Improving Quality of Seam in High-Speed Welding (V. G. Verbitskiy, I. V. Kiselevich, et al.; SVAROCHNOYE PROIZVODSTVO, No 5, May 85).....	66
Parameters of Solid-Phase Diffusion Zone Formed During Welding of Platinum to Titanium (Ye. A. Dzhur, A. N. Kvasha, et al.; SVAROCHNOYE PROIZVODSTVO, No 5, May 85).....	67
<b>MISCELLANEOUS</b>	
Production of Special Alloy for Computers' Resistor Components (VECHERNIY LENINGRAD, No 139(17629), 19 Jun 85).....	68
Fatigue Resistance of Rolls Surfaced With Electrode Strip (T. G. Kravtsov; AVTOMATICHESKAYA SVARKA, No 2, Feb 85).....	69
Effect of Mercury on Bearing Capability of Aircraft Design Components (A. I. Radchenko, N. V. Kosorukova; FIZIKO-KHIMICHESKAYA MEKHANIKA MATERIALOV, No 1, Jan-Feb 85).....	69
Influence of Temperature-Force Conditions on Working Capacity of Alloys With Shape Memory (I. N. Andronov, S. P. Belyayev, et al.; VESTNIK LENINGRADSKOGO UNIVERSITETA: MATEMATIKA, MEKHANIKA, ASTRONOMIYA, No 1, Jan-Mar 85).....	70
Review of 'Thermal Deformation of Non-Metallic Destruction Materials', Monograph by G. N. Tret'yachenko and L. I. Grachevaya, Kiev, Naukova Dumka, 1983, 248 pp (I. N. Frantsevich; PROBLEMY PROCHNOSTI, No 11, Nov 84).....	70
Design of Flange Joints of Aviation Gas Turbine Engine Stator (V. B. Zhukov; PROBLEMY PROCHNOSTI, No 7, Jul 84).....	71
Discharge in Anode Material Vapor (V. A. Sayenko, N. F. Kolemiyets; FIZIKA I KHIMIYA OBRABOTKI MATERIALOV, No 6, Nov-Dec 84).....	71
Selection of Material for Manufacture of Propeller Shaft of Ship (Ya. M. Sirak, G. N. Filimonov, et al.; FIZIKO- KHIMICHESKAYA MEKHANIKA MATERIALOV, No 6, Nov-Dec 84).....	72
Ultrapure Metals and Microelectronics (Ch. V. Kopetskiy; ZNANIYE - SILA, No 5, May 85).....	73

## ALUMINUM AND ITS ALLOYS

UDC: 669.71'781

### SPECIFICS OF INTERACTION OF BORON WITH LIQUID ALUMINUM

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 8, Aug 84 pp 21-24

GEVLICH, S. O., TYLKINA, M. I., CHERNYSHOVA, T. A., Institute of Metallurgy imeni A. A. Baykov

[Abstract] An estimate is presented of the influence of duration of contact of boron fibers with liquid aluminum and the development of chemical reactions on the properties of the fibers. Standard boron fibers 140  $\mu\text{m}$  in diameter were drawn through a melt of AD1 alloy at 10°C above the melting point of the alloy with contact time varying from 0.004 to 5 s, producing a layer not over 5  $\mu\text{m}$  thick. The metallized fibers were tensile tested. The crystallized coating was removed in a 10% aqueous HCl solution and electronographic analysis performed to determine the development of chemical interactions and identify the phases formed. Optical fractography was used to determine the influence of the condition of the surface after contact on the nature of fracture. It was found that as boron was dissolved in the liquid aluminum properties of the boron improved, while reactions resulting in the formation of aluminum borides caused deterioration of these properties. The following phases were found at the interface: solid solution of boron in aluminum,  $\text{AlB}_2$ ,  $\alpha$  and  $\beta$   $\text{AlB}_{12}$ . No oxides or spinels were found. Figures 1; references 9: all Russian. [001-6508]

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### SEGREGATION OF ALLOYING ELEMENTS AT INTERFACE BETWEEN ALUMINUM MELT AND CARBON FIBER

Moscow POVERKHNOST: FIZIKA, KHIMIYA, MEKHANIKA in Russian No 6, Jun 85 (manuscript received 12 Oct 83, final version received 23 Dec 83) pp 123-128

ZAYTSEV, A. K., BELASHCHENKO, D. K., GOLDER, Yu. G. and STEPANOV, B. N., Moscow Institute of Steel and Alloys

[Abstract] An important characteristic of aluminum-carbon composites is segregation of carbide-forming elements and impurity elements inert with respect to carbon but surface-active with respect to aluminum, further segregation of the latter impurity elements leading to their selective adsorption at the interface between aluminum melt and carbon fiber. A theoretical

analysis of the process on the basis of the Gibbs equation, applicable at low impurity concentrations, and the resulting relation for the surface adsorption coefficient was verified experimentally by quantitative x-ray spectrographic microanalysis. Specimens with a longitudinal orientation in a  $10 \times 10 \times 50 \text{ mm}^3$  volume were produced by impregnating graphite fibers with different 99.9% pure binary aluminum alloys under a pressure above atmospheric and subsequent quenching. The fibers were distributed not uniformly but in bundles of approximately 500 fibers approximately  $7 \text{ }\mu\text{m}$  in diameter, these bundles approximately  $200 \text{ }\mu\text{m}$  in diameter spaced approximately  $200 \text{ }\mu\text{m}$  apart in the alloy matrix. The gist of the experimental procedure was determining the surface concentrations of each alloying element, namely the number of its atoms per

unit surface area  $C_s = \frac{1}{s} \frac{N}{A} \frac{\rho_m}{\rho_f} \frac{(1-V_f)(1-V_f^b)}{b} \frac{\Delta^C}{100}$  (A - gram·atom of alloying element, N - Avogadro's number,  $\Delta^C = C^b - C^o$ ,  $C^b$  and  $C^o$  - concentrations of alloying element in fiber bundle and in aluminum,  $\rho_{m_b} = 2.72 \text{ g/cm}^3$  density of aluminum,  $\rho_f = 1.72 \text{ g/cm}^3$  density of graphite,  $V_f = 0.5$  and  $V_f^b = 0.8$  mean volume fractions of fibers in specimen and in bundle,  $s = 0.5 \text{ m}^2/\text{g}$  specific surface fibers). This surface concentration was gauged against the surface concentration of close-packed atoms in a monolayer  $C_s^{\text{mono}} = (2r^2\sqrt{3})^{-1}$  (r - radius of atom). The surface concentration  $C^b$  in fiber bundles was measured, with the analyzer in the scanning mode, as a function of temperature and contact time. Typical results are shown for bismuth, as function of temperature after 35 min of contact and as function of contact time at  $943 \text{ K}$ , also for copper at  $909 \text{ K}$  and  $943 \text{ K}$ , and for germanium at  $903 \text{ K}$  and  $938 \text{ K}$ . The results reveal a relation between aluminum-graphite interaction and the distribution of alloying element in these composites. No nonsegregating elements have been found. Figures 3; tables 1; references 8: 3 Russian, 5 Western.  
[196-2415]

UDC 621.762.669

#### ALUMINUM POWDER ALLOYS FOR PRODUCTION OF SINTERED MATERIALS (Review)

Kiev POROSHKOVAYA METALLURGIYA in Russian No 4, Apr 85  
(manuscript received 12 Jul 84) pp 24-28

GOPIYENKO, V. G., GOPIYENKO, Val. G. and OLESOV, Yu. G., All-Union Institute of Aluminum and Magnesium

[Abstract] While aluminum powder is used for making various parts relating to steel-aluminum wire production in accordance with the technology which has been developed at the Institute of Problems in Materials Science (UkSSR Academy of Sciences), recently more attention has been paid to aluminum powder alloys for high strength and heat resistance in sintered form. The three main developers of such materials in the USSR are the All-Union Institutes of Aluminum and Magnesium, of Light Alloys, and of Aircraft Materials. Materials

already available are sintered alloys of the Al-Cu-Mg-Al<sub>2</sub>O<sub>3</sub> group (SPAK-4 based on the AK4 alloy), the Al-Si-Ni group (SAS-1 containing 25-30% Si + 5-7% Ni), the Al-Cr-Zr-Ti group (1.5% Cr + 1.2% Zr + 0.2% Ti with 0.2% V added, 1.5% Cr + 12% Zr + 0.2% Ti with 0.2% V added), the Al-Zn-Mg-Cu group (6.2% Zn + 2.5% Mg + 1.5% Cu with 0.4% Co added the mechanically strongest of all sintered aluminum alloys), the Al-Mg-Li group (01420 alloy), the Al-Ni-Ti group (1.5% Ni + 1.0% Ti) and the Al-Ni-Zr group (1.5% Ni + 1.0% Zr) featuring also high humidity resistance at 250°C, the APN alloy (0.9-1.2% Ni + 0.3-0.6% Fe + 0.05-0.1% Ti with Al<sub>2</sub>O<sub>3</sub> added) featuring also high corrosion resistance, and the Al-Fe-Ce group (8% Fe + 3.4% Ce, 8.5% Fe + 1.5% Ce). In addition to sintered aluminum alloys, there have also been developed four groups of sintered aluminum-base high-strength and heat-resistant composites. Those containing 5-30 vol.% carbon, carbides (SiC, TiC), or nitrides (Si<sub>3</sub>N<sub>4</sub>) insoluble but dispersible in aluminum feature also high wear resistance and low friction. Mechanical mixtures of aluminum powder and nickel, cobalt, titanium, zirconium, or other metal powder are blended by exothermic sintering. The third group is aluminum powder reinforced with fibers of stainless steel. The fourth group are aluminum-polymer composites (60% Al powder + 10% C powder + 5% Pb powder + 25% epoxy varnish). Figures 1; references 23: 18 Russian, 5 Western. [197-2415]

#### STUDY OF CERTAIN PROPERTIES OF ALLOYS OF TANTALUM-ALUMINUM OXIDES

Yerevan IZVESTIYA AKADEMII NAUK ARMYANSKOY SSR: SERIYA TEKHNIЧЕСКИХ НАУК in Russian Vol 38, No 2, Mar-Apr 85 (manuscript received 5 May 84) pp 38-39

AVETISYAN, A. M., Yerevan Polytechnical Institute imeni K. Marx

[Abstract] Wide interest has been shown in coatings of Ta<sub>2</sub>O<sub>5</sub> and Al<sub>2</sub>O<sub>3</sub> for dielectric applications. The present article presents a description of technology for producing such coatings with varying amounts of each component. The coatings were produced by a diode technique of cathode precipitation. Data from the study show that increasing the amount of oxygen reduced the rate of precipitation greatly for variants with large amounts of tantalum. Large surfaces can be coated by this methodology only with difficulty due to the low concentrations of inert gas atoms in the coating and the high energy of precipitated particles on contact. Oxygen in the precipitating gas causes oxidation of the surface, and the oxidation functions as a damper on the process. For pure aluminum oxide coatings, which were also produced, the optimum amount of oxygen was found to be 0.5%, while for mixed coatings of tantalum and Ta<sub>2</sub>O<sub>5</sub> oxygen should be less than 7%, and for Ta<sub>2</sub>O<sub>5</sub> alone, more than 7%. Figure 1; references 3: all Western. [207-12131]

## PERFECTING TECHNOLOGY FOR CONTINUOUS CASTING OF ALUMINUM ALLOY INGOTS

Moscow TSVETNYYE METALLY in Russian No 6, Jun 85 pp 68-71

ZHERNOV, A. I.

[Abstract] Increasing smelting production calls for accelerated productivity in the casting process. Traditional technology has not been able to meet these demands. The authors present a proposed apparatus for simultaneous casting of 10-28 ingots in a low-level crystallizer with a thermal bed. Higher quality is also claimed as heat loss from the metal surface and the meniscus, and the clearance between ingot and crystallizer, are reduced. The metal is protected from atmospheric interaction, retardation of core shrinkage is eliminated, and smooth transfer to the crystallizer is ensured. Physio-mechanical processes and properties of the resulting ingots are equal to or surpass those obtained by other processes. Questions of labor input and system durability are also addressed. A special advantage is the precision of geometric dimensions of the ingots produced. Figures 2; references 4: 3 Russian, 1 Western.

[204-12131]

## PREDICTING PROPERTIES OF CAST ALUMINUM ALLOYS, DEPENDING ON THEIR CHEMICAL COMPOSITION

Moscow TSVETNYYE METALLY in Russian No 5, May 85 pp 85-87

OFFENGENDEN, A. A., KUPERSHTOK, Yu. Ye. and BALANAYEVA, N. A.

[Abstract] Study of composition and properties of multi-component alloys often involves regressive analysis. In developing new alloys and standards for them, minimum and maximum property values at set conditions must be known. Regressive procedures often fail to provide this information. The present article offers a procedure for determining greatest and least values using a second-degree polynomial equation based on the theorem that the direction of change in a constant function of one argument is totally determined by the first derivative of that argument. The theoretical presentation is related to mechanical properties of an alloy with 1-5% Si, 1-5% Cu, 0.25% Mg, 0.25% Zn and impurities of 0.8% Fe and 0.4% Mn. Results indicate that the authors' equation, while simpler than ones used previously is just as accurate in calculating these mechanical properties. References 8: all Russian.

[199-12131]



## MODIFYING ALUMINUM ALLOYS WITH TITANIUM

Moscow TSVETNYYE METALLY in Russian No 5, May 85 pp 76-79

NIKITIN, V. I., CHEREPOK, G. V. and SHADRIN, G. G.

[Abstract] While the production of a balanced axis fine granule in aluminum castings is attempted in various processes, columnar and fan-shaped structures often remain. A study made of the effect of titanium on aluminum alloys in liquid and solid phases showed formation of durable intermetallides that remain even in a liquid state, so that Ti additives are most promising for use in technological processes. Statistical data from various stages of processing show that titanium remains at near saturation levels during the casting process, and some is lost in waste products. Processes are recommended for obtaining alloys with the maximum number of dispersed globular and spherical intermetallide particles by various chemical and physical procedures. Experiments have shown that adding magnesium or boron, along with increasing titanium content to 4-6%, will result in a change in form to platelet or spherical granules and better retention of Ti in the alloy. Further work is recommended. Figures 1; references 14: all Russian.

[199-12131]

UDC 669.715:624.014.7

## USE OF RECYCLED ALUMINUM ALLOY WITH INCREASED ZINC CONTENT

Moscow TSVETNYYE METALLY in Russian No 6, Jun 85 pp 92-93

BALANAYEVA, N. A., BYCHKOV, Yu. B., GOLUBYATNIKOV, M. I., KUPERSHTOK, Yu. Ye. and TSIRVAVA, Yu. I.

[Abstract] Various research projects have shown that limiting zinc content to 0.5% by weight in cast aluminum alloys is not fully justified, for molten fluidity and later durability were improved at up to 2%, while long-term durability under tension and thermal durability did not begin to show decline until Zn concentrations passed 1.5%. Hardness and general durability was shown in tests to improve in a range of 1.7-3% zinc content. The present article reports on a test alloy, made at the Georgian Republic Recycled Metal Plant "Vtortsvetmet" with up to 1.5% zinc, since such an alloy makes possible more efficient use of recycled metal. The alloy was tested under the conditions surpassing those in a brick drying oven, with high moisture and heat of 200-250°C. Thus tests were at 300°C for the period of one year. Results showed that corrosion resistance, measured according to state standard guidelines, was fully sufficient for this intended use. Figures 2; references 2: both Russian.

[204-12131]

## BROADER USE OF ALUMINUM ALLOYS MADE OF RECYCLED RAW MATERIALS FOR MAKING SHAPED SEMIFINISHED PRODUCTS

Moscow TSVETNYYE METALLY in Russian No 6, Jun 85 pp 90-92

BADAYEV, V. G. and EYDUK, N. Yu.

[Abstract] Users of recycled raw materials generally prefer rejected items and scrap that meet state standards. Quality control is difficult even then, with 1.5-2 times as much iron and 2-6 times as much silicon found in such metals as in standard production alloys. This problem cannot be corrected without excessive use of aluminum. Thus the current Soviet product mix from recycled aluminum is highly restricted and is limited to developing technology where the indicated impurities can be tolerated. The authors studied molten alloy at the Leningrad Metallurgical Plant "Lenvtortsvetmet" and found it contained (by weight) 0.6-3.0% Cu, 0.2-1.6% Zn, 0.6-1.8% Fe, 0.2-2.0% Mg, 0.4-5.0% Si and 0.1-0.4% Mn; these impurities are regarded as acceptable for the indicated uses. Added zinc does not lesson mechanical properties but hardens the alloy, while increased silicon can be tolerated in complex alloys. It is important to ensure thorough mixing of the molten alloy to distribute such impurities. Several test shaped products showed advantages over pure alloys, with greater durability and corrosion resistance due to the impurities. While both standard and recycled alloys at times had low corrosion resistance, anodized coatings or paints were found to prevent damage. The tested alloys can be used for products that do not require higher purity in composition according to state standards, whereas previously recycled aluminum had to go through reduction before reuse. References 11: all Russian.

[204-12131]

AMORPHOUS METALS

UDC 539.213:536.425:537.312.6:539.26

STRUCTURAL RELAXATION AND CRYSTALLIZATION OF AMORPHOUS ALLOY Ni<sub>77</sub>P<sub>23</sub>

Moscow IZVESTIYA AKADEMII NAUK SSSR: METALLY in Russian No 3, May-Jun 85  
(manuscript received 3 Nov 83) pp 97-101

NABEREZHNYKH, V. P., MOROZ, T. T., SAMOYLENKO, Z. A. and PUSHENKO, Ye. I.,  
Donetsk

[Abstract] Electrically precipitated amorphous Ni-P alloys have received wide attention due to their simplicity of production, but little has been reported on structural relaxation processes of crystallization kinetics. The present article reports on use of electrical resistance and X-ray data to attempt to arrive at some understanding of the nature of structural relaxation in Ni<sub>77</sub>P<sub>23</sub> and to evaluate activation energy of the crystallization process. Phosphorus content was determined by a chemical method with accuracy of  $\pm 0.5\%$  atomic weight. A four-contact method for measuring resistance and temperature of a sample washed by an argon stream and other measurements showed a mixture of Ni+Ni<sub>3</sub>P phases, where samples were heated up to 973°K; where maximum temperature was up to 533°K followed by cooling to room temperature, a crystalline meta-stable phase was also observed. Features of structural relaxation were further studied by controlled heating to 473°K, followed by rapid cooling to room temperature. Electrical resistance was measured during the process, showing a complex ordering process of the atomic structure of the amorphous alloy. The process was irregular in its time dynamics. Activation energy of the I and II stage of crystallization was  $110 \pm 5$  and  $150 \pm 5$  kilojoules/mole, respectively. Figures 4; references 12: 3 Russian, 9 Western.  
[198-12131]

EVALUATION OF CONDITIONS FOR PRESERVING AMORPHOUS STRUCTURE OF MATERIALS DURING DETONATION COMPACTING

Novosibirsk FIZIKA GORENIYA I VZRYVA in Russian Vol 21, No 2, Mar-Apr 85  
pp 120-126 (manuscript received 6 Aug 84) pp 120-126

NESTERENKO, V. F. and MUZYKANTOV, A. V., Novosibirsk

[Abstract] Numerous amorphous alloys possess unique properties of durability, corrosion, and radiation resistance, etc., but their production requires rapid cooling that can be achieved only with small amounts. The present article

reports on study of detonation compacting in the hope of limiting the heating period of material during treatment, so that it will cool rapidly. Unevenness of heating both contributes to such procedures and makes them difficult to regulate for optimum effectiveness. The authors attempted to produce monolithic products while preserving their amorphous structure. Kinetic parameters of crystallization, the area of the zone heated during treatment and the temperature near the contact point, thermophysical properties of materials and critical cooling rates were monitored. The authors note that comparison of tempering processes rather than precise measurements of crystallization kinetics resulted from their research, partially due to interaction of various processes. Results were calculated that showed that the maximum temperature and the minimum cooling rate was at the point of direct contact. A formula for the cooling rate is recommended for evaluating tempering conditions of contact zones up to an amorphous state during impulse compacting. These dynamics in a laminated system were also studied in an attempt to arrive at more precise values than those obtained by Newtonian principles, which give average values only. In general the authors conclude that evaluation of standard heat conductivity parameters is sufficient to determine heat effects of detonation compacting and subsequent rapid cooling.

[191-12131]

METHODS FOR PRODUCING R CURVES AND THEIR USE FOR EVALUATION OF MATERIAL  
(A review)

Moscow ZAVODSKAYA LABORATORIYA in Russian Vol 51, No 1, Jan 85  
(manuscript received 2 Feb 84) pp 64-73

NESHPOR, G. S., KUDRYAVTSEVA, G. D. and ARMYAGOV, A. A.

[Abstract] Earlier works have suggested a unique relationship between resistance to advance of a crack  $R$  and increasing crack length for a given combination of material, dimensions, test temperature and loading rate.  $R$  curves are widely used at present to estimate the quality of metals. This article reviews the literature on phases in the development of the concept of  $R$  curves, methodologic specifics of their production and application for evaluation of materials. The experimental determination of a crack propagation resistance curve under static loading provides more complete information on materials than determination of the critical stress intensity factor  $K_c$ , which is but one point on the  $R$  curve. Figures 5; references 21: 10 Russian, 11 Western.  
[129-6508]

UDC 539.26

INFLUENCE OF BEAM DIVERGENCE ON ACCURACY OF EXPERIMENTAL-ANALYTIC  
DETERMINATION OF ANALYZED LAYER THICKNESS IN SLIPPING-BEAM X-RAY STUDIES  
OF OBJECTS

Moscow ZAVODSKAYA LABORATORIYA in Russian Vol 51, No 1, Jan 85  
(manuscript received 7 Dec 84) pp 25-27

KOLEROV, O. K., LOGVINOV, A. N., YUSHIN, V. D. and SKRYABIN, V. G.,  
Kuybyshev Aviation Institute imeni S. P. Korolev

[Abstract] A study is made of the influence of beam divergence on the accuracy of determining the thickness of the layer analyzed in slipping-beam x-ray studies of objects. The thickness of the layer of material analyzed is not constant, and is influenced by horizontal and vertical beam divergence. The influence of beam divergence can be considered by the mathematical methods presented in this work. Where the minimum divergence is  $0.61^\circ$ , the error in determining the thickness of the analyzed aluminum is 110%. Figures 3; references 6: all Russian.  
[129-6508]

COATINGS

UDC 621.793+669...69.8

STRUCTURE AND PROPERTIES OF SPRAY-COATED MATERIALS BASED ON ALUMINUM OXIDE

Minsk VESTSI AKADEMII NAUK BSSR in Russian No 1, Jan-Mar 85  
(manuscript received 26 Jul 83) pp 21-23

PIVOVAROV, V. K., MASHKOV, B. M., PAVLENKO, Z. D., MIT'KOV, N. N.,  
and GLUKHOVA, R. G., Mogilev Department, Physical-Technical Institute,  
Belorussian Academy of Sciences

[Abstract] A study is made of the structure and properties of plasma-atomized ceramic materials used in the manufacture of cups with low heat conductivity and good physical and mechanical properties. Cups studied were 100 mm in diameter, 20 mm high, 2.5-9 mm thick, manufactured of aluminum oxide and mixtures of aluminum oxide with other oxides or other materials. Studies were performed by microscopic and x-ray structural analysis, measurement of hardness, density and thermal stability. The studies demonstrated that the use of plasma atomized ceramics, a combination of two or more oxides and other elements, allows most complete utilization of the advantages of the individual components while yielding products with the required properties. Figures 2; references 3: all Russian.  
[166-6508]

UDC 621.8

CATHODE-ANODE DEVICE FOR HARDENING OF PARTS BY ELECTROLYTIC BORIDING

Kiev TEKHNLOGIYA I ORGANIZATSIYA PROIZVODSTVA in Russian No 4, Oct-Dec 84  
pp 53-54

CHEL'TSOV, V. Ya., Engineer, RAYTSES, V. B., Candidate of Technical Sciences  
and MATLAKHOVA, I. O., Engineer

[Abstract] The Zaporozh'ye Industrial Institute has developed and, in cooperation with the 'Zaporozhstal' plant, has manufactured a special cathode-anode fitting allowing boriding of the outer and inner surfaces of parts simultaneously. The new design allows the cathode fitting to be made simultaneously with the anode fitting, separated by an insulating insert. The carrier plate of the device has a projection which fits into a depression in the cathode holder. The use of the device allows assembly to be performed outside the high temperature bath or furnace, increasing the productivity of labor, reducing labor consumption and improving working conditions.  
[169-6508]

ELECTRICAL AND MAGNETIC PROPERTIES OF AMORPHOUS COATINGS OF ALLOY  $\text{Fe}_5\text{Co}_{79}\text{Mo}_2\text{B}_{14}$ 

Sverdlovsk FIZIKA METALLOV I METALLOVEDENIYE in Russian Vol 59, No 2,  
Feb 85 (manuscript received 18 Jul 84) pp 317-329

PARFENENOK, M. A., ROSIK, I. I. and DROKIN, A. I., Simferepol State University

[Abstract] Recently, amorphous soft magnetic alloys have been produced as thin ribbons by cooling a stream of the alloy, but the newest technology prefers cathode spraying. The present article reports on study of the structure and electric and magnetic properties of  $\text{Fe}_5\text{Co}_{79}\text{Mo}_2\text{B}_{14}$ , produced by ion plasma spraying on siall, leucosapphire, or polycorundum substrates. Thicknesses of 0.5-10  $\mu\text{m}$  were tested on diffractometer and vibromagnetometer equipment. Samples were produced at pressures of  $2.66-26.6 \cdot 10^{-2}$  Pa at a cooling rate of 1.8 nm/sec, at  $5.3 \cdot 10^{-2}$  Pa with cooling at 0.4-1.8 nm/sec and with varying thicknesses at the latter values. Results showed that the electrical resistance of the samples declined by 2.5 times during the transition from amorphous to crystalline state. As the thickness of the coating increased the demagnetizing factor declined in importance and the coating passed through the "critical state"; at the same time, the impact of defects became greater. Low values of  $H_c$  and high  $4\pi M_s$  values were noted among magnetostatic properties. The test alloy was judged to be useful for magnetic conductors in various applications. Figures 3; references 8: 1 Russian, 7 Western.  
[187-12131]

COMPOSITE MATERIALS

EIGHT-BLADED COMPOSITE-MATERIAL PROPELLER TESTED ON AN-32 PLANE

Moscow IZVESTIYA in Russian 12 Jul 85 pp 1, 6

[Article by V. Belikov, correspondent]

[Abstract] The article reports that a multibladed propeller made of a composite material that is reinforced with glass, carbon and organic fibers has been tested on one of the engines of a twin-engine AN-32 airplane. It is claimed that this type of propeller, which is called a prop-fan, in combination with a modern gas turbine reduces fuel consumption by 20-30 percent in comparison with existing airplane engines. It permits flight at speeds of 800-900 kilometers per hour.

The author of the article was told at the design bureau that the laboratory AN-32 with the new propeller has made it possible to test the new type of turboprop engine in real flight conditions. The propeller had undergone extensive laboratory strength and wind-tunnel tests at the design bureau and also at research institutes of the aircraft industry. The pilots were quoted as saying that the propeller functioned flawlessly. On the ground it produced higher thrust than the conventional propeller, and the noise and vibration from it were considerably less.

It is noted that for high-power engines, the developers have proposed a coaxial scheme with two of the prop-fans mounted on one shaft and turning in opposite directions. This solution reportedly will provide even more fuel economy, as well as make it possible to reduce the diameter of the propellers and to eliminate reactive torque on the wing. It is recalled that a full-size coaxial prop-fan was demonstrated in the Soviet exhibit at the latest Paris Aerospace Show.

A photograph is given showing the AN-32 with the eight-bladed propeller on the port engine, and a conventional four-bladed propeller on the starboard engine.

FTD/SNAP  
CSO: 1842/222



KINETICS OF CONDUCTANCE CHANGES DUE TO DIFFUSIONAL INTERACTION OF COMPONENTS  
IN THREE-DIMENSIONAL FIBER-REINFORCED COMPOSITE MATERIALS

Kiev POROSHKOVAYA METALLURGIYA in Russian No 4, Apr 85  
(manuscript received 10 Apr 84) pp 55-61

ZARICHNYAK, Yu. P. and UTKIN, A. B., Leningrad Institute of Precision  
Mechanics and Optics

[Abstract] An analytical method is developed for predicting both qualitative and quantitative changes in the conductance of composites with a three-dimensional fiber reinforcement structure due to diffusional interaction between the solid matrix and fiber phases during fabrication or high-temperature service, conductance being here generalized to cover not only the respective thermal and electrical properties but also the dielectric permittivity. The problem is mathematically formulated as one of calculating the effective conductivity of a composite material as the function of six variables  $\Lambda = f(\Lambda_m, \Lambda_f, c_0', d, D, t)$  ( $\Lambda_m$  and  $\Lambda_f$  - conductivity of matrix material and of fiber material,  $c_0'$  - initial volume fraction of fiber, prior to annealing or installation,  $d$  - mean diameter of fiber,  $D$  - interdiffusion coefficient,  $t$  - length of annealing period or of service). The corresponding three-dimensional differential equation for the transient concentration field in an interdiffusing two-component mixture is  $\partial^2 c_{ij} / \partial x^2 + \partial^2 c_{ij} / \partial y^2 + \partial^2 c_{ij} / \partial z^2 = (1/D)(\partial c_{ij} / \partial t)$

in an orthogonal system of space coordinates normalized to the length of respective edges in one octant of a unit parallelepipedic cell and time, with the boundary conditions  $D \partial c_{ij} / \partial \xi |_{\xi=0} = D \partial c_{ij} / \partial \xi |_{\xi=1} = 0$  ( $\xi = x, y, z$ ). The solu-

tion to this equation is sought not conventionally in the form of triple trigonometric series, which requires a retention of over 1000 terms for ensuring an accuracy within 1%, but by subdivision into three characteristic regions by intersection of three infinitely large planes and subsequent superposition, assuming an isotropic interdiffusion coefficient in each and using auxiliary planes. This method has been used for solving the analogous problem of transient heat conduction. From the solution are determined first the local properties and then the integral properties of the diffusion layer, whereupon the effective resistance and thus its inverse, the effective conductance, can be calculated directly for any instant of time. As a result is obtained the conductance transient from its initial peak to the steady-state level. Figures 4; references 14: 12 Russian, 2 Western.

[197-2415]

## FORMATION OF COMPOSITE BORIDE COATINGS BY LOW-TEMPERATURE ANNEALING OF ELECTROLYTIC DEPOSIT

Kiev POROSHKOVAYA METALLURGIYA in Russian No 4, Apr 85  
(manuscript received 18 May 84) pp 29-31

GUSLIYENKO, Yu. A., FEDORCHENKO, I. M., TIKHONOVICH, T. N. and AGARKOV, A. A.,  
Institute of Problems in Materials Science, UkSSR Academy of Sciences

[Abstract] The main drawback of conventional high-temperature (900-1150°C) annealing of composite boride coatings produced by electrolytic codeposition of amorphous boron particles and group-VII (Fe, Ni, Co) metal particles is their warping and other deformation, such coatings also not being suitable for protection of nonferrous metals and alloys. Formation of such coatings by annealing at much lower temperatures (400-600°C) has been found to be feasible, following a study of dislocation and vacancy structures in the electrolytic deposits before and after introduction of amorphous boron into the galvanic metal matrix. Microdeformations were examined under a transmission electron microscope and by the method of replicas. Measurement of the electrical resistance directly during heating and of the mechanical properties after short-duration static tension tests has established that Fe-B, Ni-B, Co-B coatings on steel, after annealing at lower temperatures for the proper length of time, will have approximately the same strength and wear resistance as those annealed at the higher temperatures. The proper annealing conditions for Ni-B coatings on grade-45 carbon steel, for example, range from 5 hr at 400°C to 2 h at 600°C. Figures 4; references 5: all Russian.  
[197-2415]

UDC 666.233

## KINETICS OF SPONTANEOUS CRYSTALLIZATION OF CUBIC BORON NITRIDE

Kiev POROSHKOVAYA METALLURGIYA in Russian No 4, Apr 85  
(manuscript received 27 Mar 84) pp 48-51

SHIPILO, V. B. and SERGEYEV, V. V., Institute of Solid-State and Semiconductor Physics, BSSR Academy of Sciences

[Abstract] Spontaneous crystallization of  $\beta$ -BN was studied experimentally in an "anvil with socket" high-pressure apparatus. Inside containers made of lithographic stone were alternately stacked graphite-like  $\alpha$ -BN pellets and  $MgB_2$  pellets, their mass ratio being 7:3, for subsequent heating up to 2000°K with the pressure stepwise raised to 4.8 GPa. The holding period at each temperature and pressure was first lengthened to 60 s in 5 s steps and then extended successively to 90, 150, 300, and 600 s. Isothermal conditions during each holding period was maintained by regulating the variable electrical resistance of the graphite heater. The apparatus was water-cooled on all sides. Tests were performed after each holding period of different length, 15 times after each, with examination under an MBS-9 microscope and an MIM-8M

microscope for a count of crystallization centers in 10 mg specimens and for monitoring the kinetics of the  $\alpha \rightarrow \beta$  phase transformation in boron nitride on this basis. An evaluation of data processed according to the Kolmogorov

relation  $\alpha(t) = 1 - e^{-\frac{4}{3} \pi J(t) v^3(t) t^m}$  ( $J(t)$  - rate of  $\beta$ -phase formation,  $v(t)$  - rate of  $\beta$ -phase growth,  $t$  - time) with the experimentally determined exponent

$m = \frac{\log[\log(1-\alpha)] - \log K}{\log t}$  ( $K = \frac{4}{3} \pi J(t) v^3(t)$ ) reveals that the crystallization

process intensifies to a peak within the first 15-20 s and then slackens down within the next 10-40 s under the given conditions. Figures 4; references 12: 11 Russian, 1 Western.

[197-2415]

CORROSION RESISTANCE AND CORROSION-THERMAL FATIGUE OF CHROMIUM-PLATED PIPES

Moscow TEPLOENERGETIKA in Russian No 4, Apr 85, pp 44-47

OTS, A. A., doctor of technical sciences, LAYD, Ya. P. and SUYK, Kh. Kh., candidates of technical sciences, Tallinn Polytechnical Institute

[Abstract] Protective coatings for pipes subjected to highly corrosive environments are in common use. The present article reports on study of chromium-plated steel 12Kh1MF produced at the Ukrainian Scientific Research Institute for Special Steels for use in the lower radiation zone (LRZ) of boilers and in high-pressure steam reheaters (HPSR), both of which operate at about 550°C. Sections of test pipe were cut and retained for later comparison, then the pipes were tested under operating conditions and compared to uncoated pipes. A formula reflecting the role of metal temperature and operating time on corrosion pits is presented. Further microtesting showed that the chromium layer applied by metallization of finished pipes had a thickness of 0.15-0.3 mm with irregularities of up to 0.1 mm before testing, and no difference after 16,300 hours of operation. Unchromed pipes had thoroughly corroded surfaces. Maximum damage depended not on temperature and time period alone, but also on supplementary factors related to installation. The relation of cross-sectional cracking to axial tension was also studied. The experimental data make it possible to predict the service life of chromium-plated pipes used in mazut boilers under maximum temperature conditions; the authors estimate a likely life of 100,000 hours for the pipes tested. Figures 3; references 8: all Russian.  
[203-12131]

ENERGY EFFECTS

UDC 535.21

PATTERNS OF MULTI-PULSE LASER RADIATION ACTION ON METAL TARGETS

Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA in Russian Vol 49, No 6, Jun 85 pp 1218-1220

KALABUSHKIN, O. I., KAPORSKIY, L. N., SALYADINOV, V. S. and SHABANOV, Ye. A.

[Abstract] Earlier works have shown that oxidation of thermally fine gauge metal sheets could be initiated by one or two pulses of a neodymium laser. The present article reports on patterns of the initiation of self-supporting combustion of such metal after micro- and millisecond laser pulses. Five free generation production lasers with 0.1 to 2.0 ms pulse duration and various combinations of several of these lasers were used in the study. Optical systems were used to focus the laser beams, and the rate of speed was varied from 0-200 m/sec<sup>-1</sup>. The self-supporting threshold of combustion for a titanium sheet as a function of the total duration of the effects of a series of pulses was determined, along with the area of irradiation, the thickness of the sheet, and the rate of speed. It was learned that a certain duration of irradiation pulses had to be determined in order to support combustion for a given thickness of titanium. Increasing the rate of speed of radiation was found to reduce the time of reaction initiation. The patterns of oxidation initiation noted provide a basis for predicting parameters of laser radiation effects that are essential for maintaining self-supporting combustion of thicker metal sheets using pulsed laser radiation. One figure; references 4: all Russian.

[208-12131]

UDC 54-31:621.373.825

FEATURES OF HEATING METALS WITH INTENSIVE RADIATION IN OXIDIZING MEDIUM

Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA in Russian Vol 49, No 6, Jun 85 pp 1214-1217

BAZHENOV, V. V., BONCH-BRUYEVICH, A. M., GAGARIN, A. P., DOROFEYEV, V. G., LIBENSON, M. N., MAKIN, V. S. and PUDKOV, S. D.

[Abstract] Among recently studied radiation phenomena, the stimulating effects of light pulses on fine metal plates has been shown to have a spasmodic nature as absorption increases. At the same time, spasmodic temperature increase may be accompanied by exothermal heat emission. The present

article reports on study of the mutual effects of pulse and constant radiation on thermally heavy-gauge titanium and stainless steel samples in air. Results showed that the CO<sub>2</sub> laser used at up to 600 W had two extremes of energy and radiation. "Slow"<sup>2</sup> and "fast" pulsed combustion of metal was found to depend on the level of quasi-stationary temperature achieved after the pulse effect, and was in turn dependent on the initial temperature. A simple increase in energy was insufficient to raise the threshold of pulse metal combustion, but raising the initial temperature made it possible to work the thermal heavy-gauge metal with relatively low-intensity constant laser beams. Figures 3; references 4: all Russian.

[208-12131]

UDC 621.375.82

#### SURFACE DESTRUCTION OF Cu and Mo-MIRRORS BY POWERFUL COHERENT IRRADIATION

Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA in Russian Vol 49, No 6, Jun 85 pp 1233-1235

AKSENOV, V. P. and ZHURKIN, B. G.

[Abstract] Destruction of the surface of metal mirrors by powerful laser irradiation has been studied from the standpoint of power optics and for purposes of laser technology. The present article reports on the process of formation of surface periodic structures (SPS) on molybdenum and copper mirrors after exposure to laser irradiation at 0.5 J for 30 ns. SPS relief and optic gas penetration are calculated considering surface electromagnetic wave, temperature and metal thickness in the target area. The equation showed that the most likely area for SPS formation was the intensive zone where temperature was a major determinant for the rate of weight loss at the target. SPS formation led to gas breakthrough, formation of plasma in the dense vapor above the mirror, and resulting intensive damage to the surface. The most effective mechanism of diffraction losses for the surface electromagnetic wave was at about 10 mcm, and avoidance of further orders of diffraction and surface plasmons was essential for the supplementary grid. Introduction of dampers into the metal system of Mo and Cu mirrors that would slow the growth of surface periodic structures contributed significantly to the radiation resistance of the metal mirrors. Figures 1; references 12: 6 Russian.

6 Western.

[208-12131]

FORMING

UDC 621.984.3:621.783.2

SHEET STAMPING OF PARTS WITH HEATING BY FLAMELESS GAS INFRARED BURNERS

Moscow KUZNECHNO-SHTAMPOVOCHNOYE PROIZVODSTVO in Russian No 12, Dec 84  
pp 32-33

ZAV'YALOVA, V. I. and MARTYNOVA, N. M.

[Abstract] The use of heating installations with quartz lamps does not allow stable production of quality parts due to nonuniformity and slowness of heating resulting from contamination of the surfaces of the radiating lamps in use. Flameless infrared gas heaters which can heat sheets and equipment directly in the press do not have these shortcomings. A cross-sectional diagram and photograph of an infrared flameless gas heating unit are presented. Experimental studies were performed to determine the influence of gas flow rate and pressure on the temperature of the ceramic packing, nichrome cover screen and blank being heated. A blank 0.5 to 3.0 mm thick can be heated to the required working temperature in 40 to 180 seconds by a burner 15 mm from the blank.

[75-6508]

PHYSICAL SIMULATION OF CONDUCTIVE-STIRRING PROCESS IN UNSOLIDIFIED MOLTEN PART OF INGOT

Riga MAGNITNAYA GIDRODINAMIKA in Russian No 4, Oct-Dec 84  
(manuscript received 23 May 83, final edition received 26 Apr 84) pp 95-100

FEDOTOV, V. M., SUBOCH, V. D, TIKHONOV, N. I., SAMOYLOVICH, Yu. A. and YASNITSKIY, L. N.

[Abstract] The process of conductive electromagnetic stirring for more homogeneous solidification of a continuously cast metal melt is analyzed by the indirect method of physical simulation, conductive stirring already known to be much more efficient and economical than inductive stirring. An electrolytic trough containing 30% aqueous  $\text{Na}_2\text{CO}_3$  solution between d.c. electrodes serves as the model, much more accessible to measurements than a large megawatt continuous-casting machine, the electrodes simulating the support and current-feed rollers in the actual process. The magnetic field is produced by an electromagnet whose two cores, each carrying two coils and closed through a yoke, simulate the electromagnetic rollers of a real casting machine. The corresponding Navier-Stokes and Maxwell equations are solved for the appropriate boundary conditions, with both thermogravity convection and Archimedes force disregarded. After reduction of this system of differential equations to dimensionless form a functional relation is established between three governing process criteria (Hartmann number  $N_H$  characterizing the magnetic field, Reynolds number  $N_R$  characterizing the hydrodynamic field, Kirko number  $N_K$  characterizing the electric field) in the form  $f(N_H, N_R, N_K) = 0$  form, the fourth criterion (Batchelor number) being eliminated by self-similarity of MHD phenomena in turbulently flowing liquid metal. The relations obtained on the basis of symmetric flow and stirring are  $N_R \approx 0.95 \sqrt{N_H N_K}$  and  $v_0 \approx 0.95 \sqrt{B_0 E_0 \sigma L / \rho}$  for the maximum velocity of stirred melt ( $B_0, E_0$  - magnetic induction and electric field intensity at center of stirring zone,  $\sigma$  - electrical conductivity,  $\rho$  - density,  $L$  - length). The preliminary design of an electromagnetic stirrer can be based on these relations, considering that the maximum melt velocity should remain within the 0.25-0.5 m/s range for steel so as to ensure negligible thermogravity convection and Archimedes forces. Figures 2; references 13: 10 Russian, 3 Western.  
[91-2415]



USE OF NICKEL PRODUCTION SLAG FOR PRODUCING GLASS CRYSTAL MATERIALS

Moscow TSVETNYYE METALLY in Russian No 6, Jun 85 pp 39-41

KRUCHININA, L. P. and KOSHKINA, L. P.

[Abstract] The authors report on use of slag from the Rega (Rezhskiy) Nickel Plant containing 39.9  $\text{SiO}_2$ , 7.94  $\text{Al}_2\text{O}_3$ , 24.15  $(\text{Fe Fe}_2\text{O}_3)$ , 17.85  $\text{CaO}$ , 5.21  $\text{MgO}$  (all by weight) and other impurities such as kaolin and limestone. Five variants of slag + various additives such as kaolin, sodium sulfate, sand and limestone, etc., were tested. During melting at 1350-1450°C the process was observed visually and later homogeneity and the presence of crystalline phases were assessed. Results showed that high-quality glass without crystallization during annealing could be produced from the nickel slag by-products. Differential thermal and X-ray analyses showed the potential for making siallic crystalline glass as well. The best technical properties were obtained with the slag containing 20 parts kaolin or 20 parts sand and 10 parts of limestone per 100 parts slag. The optimum temperature range was 800-900°C. The resulting glasses had fine crystalline (sialline) structure, which were equal to or better than analogous glasses from ferrous manufacturing slags. One figure.  
[204-12131]

## HEAT TREATMENT

UDC 537.525.1:621.793.7:621.365.2

### THERMAL PHYSICS OF PLASMA PROCESSING OF FINELY DISPERSED PARTICLES

Moscow FIZIKA I KHIMIYA OBRABOTKI MATERIALOV in Russian No 2, Mar-Apr 85  
(manuscript received 10 Oct 83) pp 13-21

UGLOV, A. A. and IVANOV, Ye. M., Moscow

[Abstract] Plasma processing of finely dispersed particles may involve long-term heating, as in plasma chemistry, or short-term processes such as plasma spraying. Carbideization, nitridation and oxygen reduction processes can damage plasma coatings. The authors evaluate convective and radiant heat exchange during the motion of fine spherical thermal particles in a low-temperature plasma stream, taking account of radiant heat exchange from the plasmatron or reactor. The calculations presented cover the process of heating fine particles to the melting point. Data showed that in a stream of isothermal gas the temperature extreme of the particles was always less than stream temperature due to radiation cooling. Further calculations show that heating time can be reduced markedly by using a gas medium with high heat capacity. Temperature limits of 15,000°K for argon and 7000-7500°K for nitrogen are suggested. Heat loss and thermophysical properties of the plasma are presented in further calculations. Figures 1; references 4: all Russian.

[179-12131]

### OXIDATION OF METAL PARTICLES IN INITIAL HEATING ZONE DURING COMBUSTION OF SVS [SAMORASPROSTRANYAYUSHCHIYSY VYSOKOTEMPERATURNYY SINTEZ (SELF-PROPAGATING HIGH-TEMPERATURE SYNTHESIS)] SYSTEM

Novosibirsk FIZIKA GORENIYA I VZRYVA in Russian Vol 21, No 1, Jan-Feb 85  
(manuscript received 1 Jul 83) pp 93-98

BLOSHENKO, V. N., BOKIY, V. A. and BOROVINSKAYA, I. P., Chernogolovka

[Abstract] The article reports on combustion of the simplest binary systems where metal and non-metal are combined and one component does not burn in the combustion front and the adiabatic temperature of combustion is below the melting temperature of the final product, which is extremely porous and has little filtrational resistance to gas. A mathematical model, simplified by excluding mass transfer factors, was developed which showed that, as a result of increasing temperature of the particles, diffusion mobility of O<sub>2</sub>

impurities became a determinant. Calculations are presented to show that with weak kinetic retardation, oxidation depended on temperature and rate of heating. The process of oxidation of titanium is considered as an example. The authors stress that the conclusions should only be regarded as approximate, and that further experimental data are required. Figures 2; references 12: 10 Russian, 2 Western.

[142-12131]

UDC 669.71'721.867

EFFECT OF THERMAL PROCESSING OF FINE STRUCTURE AND FAILURE MECHANISM OF PLASMA-APPLIED ALUMINUM ALLOYS

Moscow IZVESTIYA AKADEMII NAUK SSSR: METALLY in Russian No 3, May-Jun 85  
(manuscript received 4 Oct 82) pp 147-151

RYBIN, V. V., ALIPOVA, A. A., ALEKSEYEVA, T. N. and KUCHKIN, V. V., Leningrad

[Abstract] Previous research has suggested that supplemental plastic processing can increase the durability and viscosity of alloys based on aluminum, but little research has been published on the effect of thermal processing of pressed plasma-applied aluminum coatings on fine structure and failure mechanisms. The authors present data on Al-Zn-Mg with Mg:Zn at 0.5, and Al+6% Mg; the first was hardened thermally, while the second was not. Plates 110 x 110 x 3 mm were used to cut working samples of 25 mm in diameter and 2.5 mm thick. These were subjected to various heat treatments, then measured for tensile stretching prior to failure. Foil was also made of the metals and examined under a transmitting electron microscope. Results indicated that both alloys failed with practically no prior deformation, as numerous intergranular cracks appeared that approached delamination dimensions. The granular nature of the plasma-applied material is cited as the cause of these cracks. These failure processes were more pronounced in the Al-Zn-Mg alloy. Vacuum annealing at 500°C with compression increased failure viscosity markedly, especially in this alloy, but it was impossible to eliminate brittle granular boundaries entirely. Figures 2; references 4: all Russian.

[198-12131]

UDC 621.771.252

EFFECT OF DESIGN, HYDROMECHANICAL AND TEMPERATURE FACTORS ON INTENSITY OF ACCELERATED COOLING DURING THERMOMECHANICAL PROCESSING OF LIGHT-SECTION METALS

Moscow IZVESTIYA AKADEMII NAUK SSSR: METALLY in Russian No 3, May-Jun 85  
(manuscript received 25 Jan 84) pp 177-181

ZHADAN, V. T., SAMOYLOVICH, Yu. A., TRUSOV, V. A., KABAKOV, Z. K.,  
VORONOV, A. N., and DISTERGEFT, I. M., Moscow

[Abstract] Formation of the required rolling structure during thermomechanical processing depends in part on the rate of cooling, especially in a critical temperature zone. Since data on heat emission are incomplete, the authors

conducted a comprehensive study of design, hydromechanical, and temperature factors during accelerated cooling. The device used and the mathematical formulas tested are presented and explained. Reynolds criteria for determining the coolant flow and the motion of the rolled metal relative to the coolant are summarized. Mathematical modeling and thermocouple design for measuring temperature are described. Mathematical and experimental factors were coordinated prior to carrying out the mathematical calculations presented. Calculations for the Nusselt criterion of the forced cooling zone are presented. Results showed that as the coolant flow increased, the thickness of the laminate layer decreased, bringing more rapid heat loss. The most important factor in determining thermomechanical processing results was the temperature of the coolant on contact with the rolled material. Figures 5; references 4: 2 Russian, 2 Western.  
[198-12131]

## INSTRUMENTATION AND EQUIPMENT

### PORTABLE ELECTRIC WELDING UNIT

Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 20 Jun 85 p 4

DEMCHENKO, I.

[Abstract] The article records a conversation with Yevgeniy Fedorovich Olennikov, head of a laboratory of the All-Union Scientific Research Institute of Electric Welding Equipment in Leningrad. Olennikov described a new portable welding unit that has been developed at the institute.

This unit, which is about the size of a small suitcase, has a capacity of 1,000 watts for welding at currents ranging from 0.1 to 30-40 amperes. The unit has a non-tungsten cathode which does not require cooling during operation and which can operate continuously for about an hour without affecting the quality of welding, it is claimed. The design of the unit's electrode is said to be new in principle. The tip of this electrode is made of titanium nitride with an inclusion of rare-earth elements. It can withstand a temperature as high as 3,200 degrees. An argon-arc torch of simplified design can be employed with the unit. This torch is about the size of a ball-point pen. Olennikov noted that the new unit can be used not only for welding steel but also for joining titanium and copper sheets up to 2 millimeters thick, as well as electric conductors made of copper, tungsten, nickel-chromium alloy, titanium and other materials.

FTD/SNAP  
CSO: 1842/195

### PHYSICS INSTITUTE DEVELOPS METAL-INSPECTION INSTRUMENTS

Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 25 Jun 85 p 2

[Article by G. Novikov]

[Excerpt] The Belorussian Academy of Sciences' Institute of Applied Physics has responded swiftly to an order from metallurgists and machine builders. A method for faster and simpler inspection of the structure of metals and metal products has been developed here.

"The task of determining the hardness of a metal, which takes plant checkers an entire shift, is accomplished by our unit in 1.5-2.0 seconds," said M. Mel'guy, head of a laboratory of the institute, showing a miniature metal box with a needle indicator. A magnetic rod-type pickup was connected to this box. "We also have instruments for other purposes; we have developed a magnetic analyzer of the structural quality of products in collaboration with specialists of the 'Svobodnyy Sokol' Metallurgical Plant in Litetsk. Objects under study are dropped through the measuring device of this analyzer, and the instant this takes is enough to determine whether a part's parameters correspond to specified ones."

Devices are being developed at the institute which will monitor the quality of wire and of rods with small diameters. The scientists have also found a method for monitoring the mechanical properties of steel sheet moving at a rate as high as 5 meters per second.

FTD/SNAP  
CSO: 1842/195

UDC 669.187.2:533.9:62-115.001.5

THREE-PHASE PLASMA HEATING DEVICES AND PROSPECTS FOR THEIR USE. REPORT I  
Kiev PROBLEMY SPETSIAL'NOY ELEKTROMETALLURGII in Russian No 1, Jan-Mar 85  
(manuscript received 30 Jun 83) pp 50-55

PATON, B. Ye., LATASH, Yu. V., ZABARILO, O. S., MEL'NIK, G. A., ZAMULO, N. I., PRIKHOD'KO, M. S., GONCHARENKO, V. V. and GAYKOVICH, I. A., Institute of Electric Welding imeni Ye. O. Paton, Ukrainian Academy of Sciences, Kiev

[Abstract] Metallurgical AC plasmatrons have been developed at the authors' institute for use in plasma-arc furnaces. The use of AC plasmatrons greatly improves the ecologic conditions of production and refining of high alloy steels, alloys and pure metals. The institute has developed a new method for increasing electrode service life and stabilization of arcs--forced generation of charged particles in the electrode area of the arc. The essence of the method is that the number of charged particles required is provided in the electrode area of the arc by an independent low power arc type gas heater plasma source. Feeding of a quasi-neutral plasma into the electrode area supports uniform distribution of active spots over the surface of the electrode and decreases power consumption. The new 800-3600 kW power unit supports a broad range of metal heating and melting conditions. Long life and high arc stability are achieved by the use of the plasma electrodes in the device.

References 9: 2 Russian, 7 Western.

[122-6508]

## NONFERROUS METALLURGY

### UZBEK SCIENCE ACADEMY PRESIDENT VISITS TROUBLED ALMALK

[Editorial Report] Tashkent PRAVDA VOSTOKA in Russian on 19 March 1985 carries on page 3 an 800-word article by T. Rashidov, chief scientific secretary of the Uzbek Academy of Sciences' Presidium titled "To the City from the Academy." The article describes a recent agreement of cooperation between Uzbek republic scientists and the city of Almalyk with its Mining and Metallurgy Combine to attempt solutions to some of the social and economic problems which the young copper-mining city has developed lately. The author notes that "in spite of impressive achievements in the mining of non-ferrous metal ores, much of the equipment as well as the production processes at the combine have become dated, manual labor is high, energy resources are being used uneconomically, and environmental problems are especially severe. Hence party officials and economic managers turned to the scientists for help." A group of scientists headed by P. K. Khabibullayev, president of the Uzbek SSR Academy of Sciences, toured the sites and held a joint meeting with the workers of the city at the mining combine's Palace of Culture to discuss the fate of the city and solutions to its social and labor problems. "In the speeches of the first secretary of the gorkam M. Mirkasymov, general director of the combine V. Sigedin [and others] a clear picture of the young city with all its contradictions, hardships, and its future aspirations emerged. The outlines of future study programs could be seen in the speeches of the president and the other scientists for the first time. In covering a wide range of problems from fertilizers to testing chemical byproducts and improving electrolysis technique, academician M. N. Nabiyeu proposed creating a branch of the Chemistry Institute in Almalyk. Academician V. K. Kabulov spoke of making Almalyk an automated, "cybernetic" city through a broad program of computerization. Academician Kh. N. Baymukhamedov suggested that the program should include a profound study of the future of polymetallic ore mining as a significant element."

UDC 669.245:669.018.44

FEATURES OF STRUCTURALLY STRESSED STATE OF PHASES IN REFRACTORY NICKEL ALLOYS

Moscow IZVESTIYA AKADEMII NAUK SSSR: METALLY in Russian No 6, Nov-Dec 84  
(manuscript received 17 Feb 83) pp 159-163

SAMOYLOV, A. I., IGNATOVA, I. A., RAZUMOVSKIY, I. M., KOZLOVA, V. S. and  
DODONOVA, L. P., Moscow

[Abstract] The effect of divergences in period of crystalline gratings of the gamma- and gamma'- phases of nickel alloys is the topic of much research. The present article reports on study of the effects of temperature changes in the grating in the range of 293-1173°K in alloys containing Cr, Co, Mo, W, Al, Ti, Nb, Zr, Hf, C and B along with nickel. Results showed the development of a plastic deformation process in the most highly stressed segments of the matrix. Data on quantitative study of plasticity are presented. Two of the alloys had relatively lower levels of thermal stress compared to the third alloy. The temperature gradient of divergences in phase gratings reflected specific features of structural stress in the tested refractory alloys. These specific features are summarized. Figures 4; references 12: 7 Russian, 5 Western.  
[67-12131]

UDC 669.017.3

STUDY OF RECRYSTALLIZATION OF REFRACTORY NICKEL ALLOY

Moscow IZVESTIYA AKADEMII NAUK SSSR: METALLY in Russian No 6, Nov-Dec 84  
(manuscript received 20 Oct 83) pp 135-137

SUKHOVAROV, V. F., PECHERKIN, Ye. A., SVITICH, Yu. V. and RTISHCHEV, V. V.,  
Tomsk

[Abstract] The mechanism of removing hammered surface during annealing of deformed alloys is determined by the magnitude of the hammered surface, the annealing process and the nature of the alloy. The present article reports on study of highly alloyed EP220 refractory alloy rolled with varying degrees of deformation. The nickel-based alloy was heated in a vacuum at 1200°C, followed by 1 hour at 1000°C, 4 hours at 950°C and 4 hours of tempering in water. Then samples were rolled at 50, 90 and 98% compression at room temperature. Recrystallization annealing was conducted at 650°C for 1 and 50 hours,



and at 950°C for 1, 10 and 50 hours. Subsequent study of structure showed that at compression of 50%, recrystallization took place in a constant process with emission of laminate and globular particles. At higher compression a microduplex structure emerged, with formation of very large granules. At 950°C the recrystallization had a periodic nature. Figures 3; references 5: 3 Russian, 2 Western.  
[67-12131]

UDC 669.245.046.55

THERMODYNAMIC ANALYSIS OF CERIUM-INDUCED REDUCTION OF NICKEL ALLOYS

Moscow IZVESTIYA AKADEMII NAUK SSSR: METALLY in Russian No 5, Sep-Oct 84  
(manuscript received 4 Feb 83) pp 20-22

POKROVSKIY, V. V., GYULIKHANDANOV, Ye. L., PANYUSHIN, L. A. and VALUYEV, V. P.,  
Leningrad

[Abstract] Few reports have appeared that are devoted to reduction of nickel-based alloys by rare earth metals. The present article reports on such reduction, beginning with the simplest Ni-Ce system and including analysis of changes in free energy during dissolution of Zr, Al and other elements in iron and nickel. In the latter processes, the heat effect was dependent on the durability of bonds in the alloy. Formulas describe Ce dissolution in nickel and changes in free energy levels during various reactions. The presence of chromium in the alloy brought minimum amounts of oxygen with highest amounts of cerium. The results, which were regarded as subject to significant variations, showed the least oxygen at 0.088% cerium by weight; minimum oxygen content with increased chromium content was 0.076% by weight.  
References 10: all Russian.

[66-12131]

LOMAKO REVIEW PROBLEMS IN NONFERROUS METALLURGY

Moscow IZVESTIYA in Russian 9 Jun 85 p 2

[Article by P. Lomako, Minister of Non-Ferrous Metallurgy: "We Cannot Bury the Gold"]

[Text] Today technological progress is unthinkable without the non-ferrous, rare and precious metals. The modern-day development of the most important sectors of the national economy are tied to their utilization.

For output of non-ferrous and rare metals in our country in 1984, it was necessary to mine billions of tons of ore and rock, consume more than 100 billion kilowatt-hours of electric energy, about 8 billion cubic meters of gas and more than 25 million tons of standard fuel units.

These figures alone are sufficient to represent at what cost to the country the satisfaction of the needs of the national economy for our sector's product is achieved. And the urgent need for thrifty consumption and conservation, in a manner beneficial to the state, of a national treasure of the Motherland--non-ferrous metals--at each step in their processing, in each link in the technological chain of production in all sectors requiring our product.

In our sector there is considerable work on-going to improve the engineering and technology of mining and production of non-ferrous metal ores. It is intended to achieve an increase in output of the metals during the 12th Five-Year Plan not only by increasing the mining and processing of ores, but by better utilization of raw materials as well. Here machine builders are called upon to play an important role. They must shift from production of individual types of machines to the manufacture of finished complexes of mining, crushing and grinding concentration equipment which operates at high speed, which in turn provides higher labor productivity indicators and an increase in the extraction of the valuable constituents. We are also awaiting aid from Minkhimprom [Ministry of the Chemical Industry] in the matter of the delivery of new chemical reagents which are very necessary for increasing the extraction of metals from ores.

One of the most important trends in the scientific and technical progress of metallurgical production is the incorporation of resource-conserving technologies and new equipment. In recent years principally new engineering processes have been created by Soviet scientists and metallurgists in production of nickel, copper and lead. They make it possible to do the smelting with significantly smaller fuel consumption.

In the sector there are many enterprises working on low- and no-waste technologies. A comprehensive technology for processing nepheline raw materials to produce high-quality alumina, soda, potash and cement has been developed and incorporated for the first time in world-wide practice at the Volkhov aluminum plant, in the Pikalevskiy association "Glinozem [alumina]" and at the Achinskiy alumina combine. Raw material which is difficult to process, intermediate products and production wastes are being brought into production of non-ferrous metals more and more at the Ministry's enterprises. During the last 4 years, the utilization of these resources has grown by a factor of 2.3.

We have succeeded in satisfying the requirements of the national economy for rolled non-ferrous metals practically without increasing its output tonnage by increasing the portion of economical and less metal-intensive types of products during the current five-year plan.

This is only a good beginning. Time and our advancement inexorably require more of us. It remains for us to increase production of a highly efficient product during the 12th Five-Year Plan. We have a strong need for precision rolled goods and other products. However, the rolling mill operators need the assistance of the Ministries of Heavy Machine Building, Electrical Equipment Industry, Machine Tool Building, Means of Automation and Control Systems.

It is also necessary to improve the existing system of product delivery planning, its market. Expansion of the assortment of rolled products produced at non-ferrous metal working plants is being constrained by the low weight of numerous orders. More than half of them are for a weight of less than one ton each. Because of this, it is often necessary to re-set highly productive equipment, which, in turn, leads to increased metal losses and an increase in labor costs. The need has become more critical to make orders larger and expand within the organizations of Gosstab USSR [State Committee of the USSR Council of Ministers on Supply of Materials and Equipment] services related to preparation of rolled materials from non-ferrous metals to meet demand, to produce cut-out articles by consumer orders and cut and package products in small batches.

Satisfying the needs of the national economy with non-ferrous metals should be determined to no small measure by more efficient utilization of a secondary metallurgical raw material--the scrap and tailings of non-ferrous metals at consumer enterprises, as well as at plants of USSR Mintsvetmet [USSR Ministry of Non-Ferrous Metallurgy].

Already, even given a far from complete utilization of secondary metallurgical raw material, as much non-ferrous metal is produced from scrap and tailings as is equivalent to the mining and processing of tens of millions of tons of ore! It is much less costly to convert scrap and tailings into commercial metal than to get it from ore which is, moreover, poor in content. Labor productivity when smelting melts from scrap and tailings is greater by a factor of 2.5 than when producing it from raw ore, and electric energy consumption per ton of recycled aluminum is many times less than during production of primary aluminum, it must be emphasized that the industry has mastered the production of high-grade recycled aluminum alloys which are in no way inferior in quality to primary alloys.

However, the situation with collection, storage and processing of scrap and tailings remains unsatisfactory as before. Sixty percent of the tailings of various types and grades of non-ferrous metals which are turned over for processing are mixed up and contaminated. This often makes their processing impossible.

I recently had occasion to become acquainted with non-ferrous metal consumption at the First State Bearing Plant. It made a very unsightly impression. In the manufacture of brass separators, the costly material is being used at a rate of only 20-25 percent. The storage and accounting for items made from non-ferrous metal is not organized, and a part of it is lost in industrial trash. Unfortunately, this is not an isolated example. At many machine building plants, the use of non-ferrous metals does not exceed 50 percent and sectors for primary processing of scrap and tailings have not been established.

The irreversible losses of nickel, copper, zinc and cadmium with depleted solutions of electroplating plants are extremely significant. In particular, at the Kamyshlovskiy Electrical Equipment Plant and the Smelyanskiy Electrical Repair Plant, which belong to the Ministry of Railways, hundreds of kilograms of nickel and zinc are thrown into the rivers.

Unfortunately, just as before, scrap and tailings of non-ferrous, rare and even precious metals are often taken away to municipal and plant dumps, where they are irretrievably lost. Recently the author of these lines was on the outskirts of Moscow at one such dump, unambiguously called "solid waste burial area." Over a period of several hours, trucks from seven enterprises dumped about 700 kilograms of non-ferrous metals; among them were silver and even... gold plated wires and contacts from various pieces of equipment. The "Svoboda" factory, the "Avangard" plant, the Institute of Geology and Development of Fuel Minerals and others have also displayed such scandalous mismanagement. Of course, measures to punish the guilty have been taken. But is this really the point? There are more than 100,000 users of non-ferrous metals in the country! Specialists estimate that tens of thousands of tons of non-ferrous metals are dumped out with the trash annually here, in other words tens of millions of rubles.

To improve the use of non-ferrous metals within the national economy, and the further development of recycled non-ferrous metallurgy, State Inspection for Non-Ferrous Metals has been established within the Mintsvetmet SSSR [USSR Ministry of Non-Ferrous Metallurgy]. Its mission is to effect control of effective and efficient utilization of non-ferrous metals in the national economy and to pose a firm barrier to all manifestations of waste, mismanagement and technical backwardness. One must hope that the work of this organization will find broad support from the local organizations and collectives of enterprises and will produce perceptible results.

The large enterprises of the machine building ministries--those who submit the scrap--should use their own non-ferrous metal tailings more fully. This will help save up to 90 tons of primary metals by as early as 1986.

There are also many supplementary reserves. Less than half of the household radio electronic equipment which falls into disuse (radio receivers, television sets, etc.) are collected from the populace. Meanwhile, there is in each

such piece of equipment up to 1.4 kilograms of copper, 0.25 kilograms of aluminum, 95 grams of nickel, 62 grams of tin, etc. on the average. Therefore, it is very important to increase collection of this scrap from the populace, including those living in rural areas. A no less valuable raw material for reproduction of non-ferrous metals is voltaic power sources which have gone out of use, or, speaking more simply, the batteries used in domestic instruments and equipment (radio receivers, tape recorders, children's toys, flashlights, etc.). However, collection of voltaic power sources which have gone out of use is not as yet organized in the country. They are thrown out at dumps along with domestic solid wastes. In a word, the collection of domestic non-ferrous scrap from the populace requires serious improvement. This is a significant and poorly used reserve.

At the April (1985) Plenum of the CPSU Central Committee, they spoke about the fact that it is necessary to engage decisively in the battle with waste and losses. This has a direct relation to the conservation of non-ferrous, rare and precious metals, in the production of which the enormous labor of hundreds of thousands of geologists, miners and metallurgists has been invested.

9194

CSO: 1842/190

CHANGE IN REFLECTIVE CAPACITY AND THERMAL DURABILITY OF METAL ALLOYS DURING SELECTIVE OXIDATION

Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA in Russian Vol 49, No 6, Jun 85 pp 1221-1223

GAGARIN, A. P., DOROFYEV, V. G. and PUDKOV, S. D.

[Abstract] Presently production of metal mirrors is limited to chemically pure metals, due to the electrical resistance and infrared absorption of alloys. The present article reports on study of the effect of Al and Be on optical properties of a copper mirror. The process of selective oxidation used to produce the mirror under oxygen pressure provided protective coatings as well as limitation of infrared absorption. Reflective capacity was measured before and after oxidation, which resulted either from residual gasses or from an oxygen medium. X-ray-electron spectroscopy was used on some samples as well. Results indicated that absorption was reduced after the coating and subsequent exposure for 2-4 hours to temperatures of 200°C, for samples annealed in air, and 400°C, for those subjected to vacuum processing. The samples developed thorough coatings of oxides of the additive metals, but no copper oxide was discerned. BeO coatings reached 60-100 Å when temperature was increased to 420°C, with zones of internal oxidation to a depth of as much as 300 Å. In general, results indicated the effectiveness of selective oxidation for changing absorption and thermal durability of metal alloys. Figures 3; references 6: 4 Russian, 2 Western.  
[208-12131]

STUDY OF EFFECTS OF IONIZING IRRADIATION ON NITRIDING OF METALS

Moscow KHIMIYA VYSOKIKH ENERGIY in Russian Vol 19, No 1, Jan-Feb 85  
(manuscript received 8 Feb 84) pp 50-54

FOMIN, O. K. and CHEVYCHELOV, V. A., Scientific Research Physicochemical  
Institute imeni L. Ya. Karpov

[Abstract] Radiational chemical nitrogen fixation releases only a small quantity of radiation-chemical products, and attempts to increase those yields have had little success. The present article reports on attempts to increase such yields by use of preliminary ionizing irradiation to accelerate nitriding of metal powders. The apparatus used is diagrammed and its functions summarized. Nitrogen with small amounts of oxygen, CO<sub>2</sub> and water was introduced into a closed chamber where it could react with Mg, Al, Ge, Zr, Ta, W, or Fe powders while being subjected to gamma radiation. Subsequent study of the effect of the radiation showed that while changes were not immediately apparent or uniform, they were of significance. Nitriding of Mg, Al and W was accelerated, while for Zr it was inhibited. For other metals it was not significant. The variations are attributed to the physicochemical and surface nature of individual metals and the nitrides formed; these factors require further study. Figures 3; references 11: 7 Russian, 4 Western.  
[95-12131]

HEAT CONDUCTIVITY OF CERTAIN SELF-PROPAGATING HIGH-TEMPERATURE SYNTHESIS SYSTEMS BASED ON ALUMINUM

Novosibirsk FIZIKA GORENIYA I VZRYVA in Russian Vol 21, No 1, Jan-Feb 85  
(manuscript received 17 Nov 83, in final form 23 Mar 84) pp 98-104

ALEKSANDROV, V. V., GRUDZEV, V. A. and KOVALENKO, Yu. A., Novosibirsk

[Abstract] Widely used pressed powder systems have high heat resistance, hardness, corrosion resistance and other advantages. Little research has been done, however, on combustion processes in gasless and low-gas systems that are very important heat conductors. The present article reports on experimental study on heat conductivity of metallic powder mixtures based on aluminum and basic patterns of changes related to porosity. Durability related to individual mechanical and structural properties affected porosity of various tested systems. Heat conductivity measurements, which took account

of adiabatic conditions for heating the overall mass, were registered on a specially developed lambda-calorimeter. Data showed that in the temperature range of 20-200°C, temperature was not a major factor in determining heat conductivity. Porosity was a more important property, especially in samples of aluminum plus other metals. Thus mechanical and thermophysical properties were found to be effective in determining heat conductivity, along with the well-known contact theory of pressing powder systems. Figures 5; references 21: all Russian.  
[142-12131]

UDC 621.762.224.01

#### OPTIMIZATION OF COMMINUTION PROCESS IN INDUSTRIAL PRODUCTION OF POWDER FROM STEEL CHIPS

Kiev POROSHKOVAYA METALLURGIYA in Russian No 4, Apr 85  
(manuscript received 25 Nov 83) pp 1-5

ESIKMAN, V. L., KIPARISOV, S. S. and PADALKO, O. V., Moscow Institute of Fine-Chemical Technology

[Abstract] Mechanical comminution of steel chips from lathes and other machine tools, for production of steel powder, has been organized on an industrial scale. The crusher forces necessary for this process are determined by the chip geometry and the chip behavior, diminution of the chip size being accompanied by regularization of the chip shape, and the corresponding size-load relation provides the criterion for mill selection and design. Subsequent optimization of the process is based on minimization of crushing energy and combining maximum energy efficiency with maximum economy. This generally requires staging and cycling of the process, with successive passes through different mills. Four types of crushers are considered for steel chips, ShKh15 being a representative grade of steel, namely: conical jaws, rotary mallets, ball mills, and jet blasts. A comparative evaluation serves as basis for optimizing the combination and the sequence of crushing modes. Figures 4; references 8: 6 Russian, 2 Western.  
[197-2415]



ACTIVATION OF MECHANICAL DEFORMATION OF ALLOY Zr + 2.5% Nb WITH ACCELERATED ELECTRONS AND ELECTRICAL CURRENT

Moscow IZVESTIYA AKADEMII NAUK SSSR: METALLY in Russian No 1, Jan-Feb 85  
(manuscript received 14 Jan 82) pp 162-163

MOISEYENKO, M. M., TROITSKIY, O. A. and GLAZUNOV, P. Ya.

[Abstract] Alloy samples 30 x 5 x 0.1 mm were tested under a constant stress of 118 N (1) when heated in an oven to 300°C, (2) when heated to 300°C and simultaneously subjected to electron radiation, (3) and when heated to 110-120°C by alternating or pulsed currents. Initial irradiation was with 5.5 MeV electrons and an intensity of  $0.5 \times 10^{14}$  electrons/cm<sup>2</sup> sec. Under these conditions there was a noticeable increase in speed of creep, apparently caused by energy from the drifting electrons being passed to structural defects, causing plastic deformation of the metal. Higher intensities produced less total deformation, probably due to simultaneous radiation hardening of the sample. Irradiated samples also showed a broadening of x-ray diffraction lines attributed to localized points of tension formed by groupings of radiation defects; this broadening was not noted in samples heated without irradiation. Electrical current also increased deformation with a pulsed current having a larger effect than alternating current. Figures 2; references 3: all Russian.

[116-12672]

NATURE OF SPLITTING FAILURE OF MOLYBDENUM, NICKEL AND TITANIUM

Kiev PROBLEMY PROCHNOSTI in Russian No 4, Apr 85  
(manuscript received 31 Jan 81) pp 64-66

GOLUBEV, V. K., NOVIKOV, S. A., SOBOLEV, Yu. S. and YUKINA, N. A., Moscow

[Abstract] Determination of durability features for construction materials that are subjected to extreme dynamic loads is a major task to which little attention has been given. The present article reports on study of a broad range of splitting failures of basic construction materials, focussing particularly on molybdenum, nickel and titanium. Disks 50 mm by 8 mm for Mb and Ti, and 10-mm-thick nickel disks, were annealed (at 1100°C for Mb, 800°C for Ti

and 400°C for nickel), then subjected to extreme loads while parameters of compression and impact resistance were determined. Despite a protective ring, the molybdenum showed cracking readily, indicating a highly brittle nature. Titanium showed a more viscous character in cracking patterns. The nickel was somewhat more durable after annealing. Features of basic structure are related to these failure patterns. Figures 6; references 6: 4 Russian, 2 Western.  
[168-12131]

UDC 546.34.882

#### CHANGES IN PROPERTIES OF NIOBIUM ALLOYS AFTER EXPOSURE TO LITHIUM

Kiev FIZIKO-KHIMICHESKAYA MEKHANIKA MATERIALOV in Russian Vol 21, No 2, Mar-Apr 85 (manuscript received 26 Aug 83) pp 80-83

MAKSIMOVICH, G. G. and IGNATIV, M. I., Physico-Mechanical Institute imeni G. V. Karpenko, UkSSR Academy of Sciences, Lvov

[Abstract] Property stability in construction materials that must operate in contact with molten metals depends on the solubility of such metals as a whole or their components under the molten conditions. The present article reports on the effect of redistribution of nitrogen, carbon and oxygen impurities and penetration of the liquid melt into the solid metal on changes in mechanical characteristics of NbPl-1 niobium and alloys NV-7, SB-1, NTsU and 5VMTs. Samples were placed in niobium ampules and filled with a lithium melt in an argon medium at 300°C. Impurities added were 1.5% nitrogen, 0.36% carbon and 0.02% oxygen (by weight). The ampules were heated and retained at 700°C for 10, 100 and 1000 hours, after which the lithium was washed away with butanol and water. Corrosion products were identified using an etching liquid of equal parts of HF, HNO<sub>3</sub>, H<sub>2</sub>SO<sub>4</sub> and water. Results showed that after 10 hours lithium penetrated NV-7 to a depth of 0.02 mm, while after 1000 hours the alloy corroded completely. Other materials did not corrode, but changes in properties were linked to redistribution of non-metallic impurities. Nitrogen had a greater impact than carbon on refractory metals, with higher diffusion mobility and concentration in lithium. Carbon affected the durability of niobium alloys less than did nitrogen. Nitrogen saturation enhanced durability, while lithium corrosion weakened them. Figures 4; references 8: 6 Russian, 2 Western.  
[174-12131]

SINGLE CRYSTALS

UDC 669.017:539.3:669-172

BOND OF ELASTICITY EXTREME AND PHYSICAL CHARACTERISTICS OF THREAD-LIKE MONOCRYSTALS

Moscow IZVESTIYA AKADEMII NAUK SSSR: METALLY in Russian No 3, May-Jun 85 (manuscript received 11 Jul 83) pp 144-146

KANCHEYEV, O. D., Moscow

[Abstract] Physical models proposed for determining maximum shear pressure for crystals have not been soundly developed, and at times have been in conflict with experimental data. Using notions of the equivalence of thermal and elastic energy, leading to loss of rigidity in the crystalline structure and loss of resistance to changes in form, the authors calculated theoretical values for the physical elasticity extreme. They present a formula based on elastic tension of a crystal sample, which they regard to be of high accuracy for cadmium and iron. A further calculation considers that the diameter of thread-like monocrystals is inversely proportional to their durability during a hardening process. They conclude that a structural-energy approach to durability and material failure can be used to combine diverse experimental data and determine maximum theoretical durability and the maximum elasticity limit. The elasticity extreme is also tied to the melting point and changes in heat content between test temperature and the melting point. Figures 3; references 19: 9 Russian, 10 Western.  
[198-12131]

## STEEL

### TECHNOLOGY FOR MAKING HIGH-SPEED STEELS WITHOUT COSTLY ALLOYS

Moscow NTR: PROBLEMY I RESHENIYA in Russian 28 May-10 Jun 85 p 5

[Excerpt] The threat of an anticipated shortage of alloying materials has driven scientists around the world to intensify their search for new 'economically alloyed' high-speed steels.

The Azerbaydzhan Academy of Sciences' Physics Institute has developed technology for thermal hardening of all classes of high-speed steels (it imparts higher physical-mechanical properties to them). High-speed steels which contain no tungsten and only an 'economical' amount of molybdenum can be produced by it.

The technology is based on new principles of obtaining a highly dispersed structural state not only of tool steels, but also of structural, spring and other types of steels.

Structural steels made using the new principles possess heightened strength and also a high level of plasticity and resistance to failure. Most important, their high-temperature strength is heightened in the process.

After heat treatment of one of the structural steels made by the new technology, the time to failure at high temperatures and stresses was 13,000 hours, whereas in similar tests this steel fails in 24 hours following conventional heat treatment.

Moreover, thanks to a fine-grain structure the steel can be deformed by 99.99 percent in the cold state without intermediate softening heat treatment. For example, a rod 8 mm in diameter was drawn out by means of deforming into a high-strength wire that was only about 1/40,000 as large in diameter.

Over 3 million cutting tools made of the new non-tungsten steels and about 250 million items of cutting tools made of conventional steels but hardened by the new process already have been introduced into production. Their economic benefit is determined here by the fact that at least 60 kilograms of tungsten and 20 kilograms of molybdenum are saved in each ton of the new steel. At the existing rates of consumption of steels of this class in the country, even their partial replacement by the new ones will help to save hundreds of tons of tungsten and molybdenum annually.

FTD/SNAP  
CSO: 1842/195

UDC 669.187.2:65.012.001.5

IMPROVEMENT OF CONTROL OF DEVELOPMENT OF SPECIALIZED ELECTROMETALLURGY

Kiev PROBLEMNYY SPETSIAL'NOY ELEKTROMETALLURGII in Russian No 1, Jan-Mar 85  
(manuscript received 21 Oct 83) pp 67-70

IVANOV, I. N., ASTAKHOVA, N. I. and VIKHREVA, R. K., Institute of Control  
imeni R. S. Ordzhonikidze, Moscow

[Abstract] Specialized electric steel melting processes including electric slag, vacuum, arc, plasma arc and electron beam remelting, as well as vacuum induction and plasma melting, have created new capabilities for the production of very high quality steels and alloys. Analysis of the current state of Soviet specialized electrometallurgy indicates that the potential capacity of the new branch is not being fully realized. Greater capital investments are required to retire obsolete installations and develop new and more modern ones. In an attempt to make a beginning toward effective management of this branch of metallurgy, the authors have determined the most important areas for future development of this branch of this industry, constructing a tree of goals with the root goal being increasing the economic effectiveness of specialized electrometallurgy. The four-level tree generates such specific first tasks as improvement of the utilization of capital investment, increasing the scientific accuracy of prospective plans, improvement and standardization and expansion of the range of branches of industry consuming the products of specialized electrometallurgy.  
[122-6508]

UDC 534.222.2

SUPPRESSING CRACK GROWTH DURING DETONATION STRAIN HARDENING OF METALS

Moscow FIZIKA I KHIMIYA OBRABOTKI MATERIALOV in Russian No 2, Mar-Apr 83  
(manuscript received 5 Sep 83) pp 138-139

DIDYK, R. P. and GRYAZNOVA, L. V., Dnepropetrovsk

[Abstract] The results of metallographic and metallophysical study of the curing zone of cracks during detonation processing of cylindrical steel samples are presented. Crack formation was shown to have a trans-crystalline nature with failure at the brittle perlite granules, indicating a brittle destruction mechanism. The spread and interaction of shock waves in cylinders of steel 35, 40 mm in diameter, were measured during repeated shock waves.

Patterns observed indicated that despite their orientation, cracks closed with significant plastic deformation, with varying structures in the closed cracks. Ferrite and perlite granules with as much as 90% deformation were observed. A "white layer" that formed in the metal was further analyzed, showing that it contained increased amounts of manganese and silicon and reduced iron content. Detonation welding was judged to be the cause of crack closing. Inconsistent parameters and tension factors are also involved in crack curing. References 5: all Russian.  
[179-12131]

UDC 539.385:620.184.6

#### FATIGUE STRIATION STEP AND CRACK GROWTH RATE

Kiev FIZIKO-KHIMICHESKAYA MEKHANIKA MATERIALOV in Russian Vol 21, No 2, Mar-Apr 85 (manuscript received 25 Jun 84) pp 55-62

GRINBERG, N. M., Physico-Technical Institute of Low Temperatures, UkSSR Academy of Sciences, Khar'kov

[Abstract] The advent of electronic fractography made possible the study of fatigue striations as a factor of fracture microrelief permitting prediction of the position of future fractures. Original notions about the mechanism of fatigue cracks being uniform throughout the second stage of their development have, however, recently been modified on the basis of more sophisticated fractographic and structural studies. The difference between macro- and micro-rates of fatigue failure is the greatest for alloys with hampered plastic deformation processes. The present article presents the patterns for steel with 3.7% silicon, where a wide range of crack lengths is found. The striation step is independent of the range and medium in which the metal was tested. Similar phenomena were observed for IMV6 magnesium alloy at room temperature in air and at 140°C in a vacuum. Determination of the striation step during stage II of failure was possible by analyzing the relationship between the fatigue striation step and crack macrostructure. Figures 6; references 54: 23 Russian, 31 Western.  
[174-12131]

UDC 624.075.22

#### DESIGN OF STEEL STRUTS WITH UNIFORM OR STEPWISE VARYING CROSS SECTION FOR STABILITY WITHIN ELASTOPLASTIC RANGE UNDER ARBITRARY LOAD

Kiev PROBLEMY PROCHNOSTI in Russian No 9, Sep 84  
(manuscript received 7 Dec 82) pp 67-71

MULLAGULOV, M. Kh., Ufa Institute of Aviation, Ufa

[Abstract] A graphical procedure is developed for stability design of steel struts under compression within the elastoplastic range. It is based on the empirical relation for critical stress as linear function of the slenderness ratio  $\sigma_{cr} = \alpha - \beta \lambda$  according to F. S. Yasinskiy. One graph is a family of

experimental  $\sigma_{cr} = f(\lambda)$  curves for series of soft and hardened carbon and alloy steels, with an Euler hyperbola drawn for the elastic range and another hyperbola parallel to it drawn through the points of transition from linear to nonlinear segments of those curves. The numerical parameters  $\alpha$  and  $b$ , both functions of the yield point, are determined from the two respective curves on a graph which, for reference, includes also the analogous curve for the coefficient in the parabolic relation according to J. B. Johnson. The data for these graphs are based on tests made at the Institute and cover 23 grades of structural steel. The procedure is, for illustration, applied to three design problems: 1) hinge-supported beam of 40Kh steel; 2) column of KhVG steel with clamped lower end and free upper end; 3) beam with step change of cross section. The second problem is solved by reduction into the elastic range. The third problem is solved by reduction to an equivalent uniform-section beam. Figures 2; references 5: all Russian.  
[29-2415]

UDC 621.91

#### PLASMA-MECHANICAL WORKING OF DIFFICULT-TO-WORK STEELS

Kiev TEKHNLOGIYA I ORGANIZATSIYA PROIZVODSTVA in Russian No 4, Oct-Dec 84  
pp 44-45

MIKHAL'KOVA, S. A., Engineer and SOLOD, A. V. (Deceased), Engineer

[Abstract] Studies were performed to determine the effectiveness of using plasma-mechanical working in metallurgical machine building. Studies included selection of optimal types of hard alloys and development of the design and geometry of cutting tools, establishment of optimal mechanical and electrical conditions of the process and evaluation of the quality of the surface after treatment by the plasma-mechanical method, as well as studies of power consumption of the process and temperature characteristics. The depth of the softened zone of the material worked by plasma heating under optimal mechanical and electrical conditions, differing for each material worked, must correspond to the feed of the tool. Conditions can be recommended for working of materials to ensure that this is so.

[169-6508]

## STEEL INDUSTRY MINISTRY NEGLECTS ROLLING-DRAWING PROCESS

Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 9 Jul 85 p 1

[Article by Ye. Tkachenko, correspondent]

[Excerpt] Lying next to a perfectly smooth, shiny sheet was a dull sheet of brass that had buckled in places. Doctor of Technical Sciences V. Vydrin's reply to my question about the advantages of a new rolling method could not have been more graphic. Both of these sheets had come from shops of the Balkhash Nonferrous Metals Plant, off the same mill. The first sheet, it must be noted, was produced after the mill had been modified with the help of scientists of the Chelyabinsk Polytechnical Institute.

A fundamentally new "rolling-drawing" process developed by Professor V. Vydrin has opened up broad prospects for radically improving the quality of metal products with minimal costs. Moreover, the process is effective in working both soft, nonferrous metals and superstrong steels.

"The equipment modernization that we did using the Chelyabinsk scientists' advice has made it possible to improve our sheet metal products to the level of high requirements which clients now demand," said K. Grechanyy, director of the Balkhash plant.

The reconstruction of a "1200" mill that produces transformer steel is nearing completion at the Novolipetskiy Metallurgical Complex imeni Andropov. Studies made by scientists of the USSR Academy of Sciences and a number of institutes have shown that both the quality of steel sheet itself and the electromagnetic properties of the metal are to be improved. Moreover, the "rolling-drawing" process will make it possible to control physical-technical characteristics of the metal, so that the product does not have to undergo laborious and inefficient additional operations for improving its quality. The precision of the rolling process in comparison with the conventional method is 50-100 percent higher.

An "800" experimental-industrial mill at the Novosibirsk Metallurgical Plant imeni Kuz'min is the first of its kind in the country to possess the advantages of the new technology. Many foreign specialists are very interested in its operation. The invention of Professor V. Vydrin and his colleagues has been patented in Great Britain, Italy, the United States, Japan and other capitalist countries. Japanese and West German firms have built a number of



mills that operate by the "rolling-drawing" method. Moreover, plants that have bought these mills are keeping their advantages secret from competitors. While introducing this process, Japanese firms have at the same time been vigorously attempting to patent their proposals for the advancement of this method, particularly its automation.

Unfortunately, it is difficult to cite examples of such vigorous and far-reaching action on the part of the USSR Ministry of Ferrous Metallurgy. Moreover, no reply has yet been received to proposals for the broad introduction of the process in the industry (particularly in equipment modernization) which were drafted by the institute as long ago as 1979 and submitted to the ministry's technical administration.

Because proper returns have not been received on this invention, the country's economy has lost tens of millions of rubles during the last three years alone, according to the most conservative estimates of specialists.

FTD/SNAP  
CSO: 1842/222

## PROMISING BEARING MATERIALS

Moscow AVTOMOBIL'NAYA PROMYSHLENNOST' in Russian No 5, Mar 85 p 36

ZIMINA, K. P.

[Abstract] Roller bearings, which play an important role in machinebuilding, require constant design and material progress. The author reports on Soviet advances in such areas as new slightly alloyed steels (eg., one called "DI36-Sh", developed at the All-Union Scientific Research Institute for Bearing Production) for use at temperatures up to 520°C. Also developed there is a heat-resistant steel-titanium alloy with 7% less tungsten but 1.5-2 times the viscosity of production bearings, along with improved malleability and polishing properties. Thermal processing of the latter alloy, labeled D143-Sh, includes tempering in salt baths or vacuum ovens, heating to 1410-1430°K, and cooling in oil. Another alloy, labeled EP940-VI, is intended for bearings that operate in corrosive environments. It contains tungsten and balancing amounts of chromium, nickel, and aluminum. Research is increasing useful life through use of vacuum-treated steels is also discussed. Chromium steel of this type is produced at the Donetsk Metallurgical Plant for pipes and bearings. Economy of raw material use is another important consideration addressed by the author; for this reason research into combinations of plastics and metals is under way. Another approach to saving precious nonferrous metals is re-use of waste metals, which is also the subject of research. [1842-186]

UDC 621.785:535.211:669.15-194:669.017

## SURFACE OXIDATION OF STEEL DURING LASER IRRADIATION

Moscow IZVESTIYA AKADEMII NAUK SSSR: METALLY in Russian No 3, May-Jun 85  
(manuscript received 23 Sep 83) pp 190-192

GUBENKO, S. I., Dnepropetrovsk

[Abstract] Laser irradiation in air often is accompanied by oxidation of steel and subsequent optical and absorptive changes. The present article reports on study of R6M5, 08GSYuTF, E3, 08Kh18N10T, 08KP, 08Yu, 08Kh, 08T, NB-57 and ShKh15 steels during irradiation to determine the nature of oxides formed. Oxides were studied by a metallographic method in light and dark fields, and their composition was determined by micro-X-ray spectral analysis.

Electric power was approximately 3 kW, time of exposure 200 sec, and depth of treatment about 10 mcm. Results showed that the metal oxides consistently formed in the liquid phase of the metal during irradiation; the oxide film did not totally cover the work area of the laser, but only parts of it. The oxides formed rapidly and at times cooled before spreading, thus forming droplets. Insufficient previous research made it impossible to analyze this factor thoroughly. While components other than iron and oxygen were present in minor amounts, they did affect the composition and structure of the oxides. The oxides could be removed effectively with a 20% solution of  $H_2SO_4$  with coking-chemical additives at 70-80°C, for 10-20 sec. Figures 2; references 6: all Russian.  
[198-12131]

## TITANIUM

### SELF-PURIFICATION OF CBC TITANIUM CARBIDE FROM IMPURITY OXYGEN

Novosibirsk FIZIKA GORENIYA I VZRYVA in Russian Vol 20, No 6, Nov-Dec 84  
(manuscript received 1 Jul 83) pp 90-94

BLOSHENKO, V. N., BOKYY, V. A., BOROVINSKAYA, I. P. and MERZHANOV, A. G.,  
Chernogolovka

[Abstract] An experimental study is presented of self purification to remove impurity oxygen in CBC systems on the example of the simplest Ti + C system. The carbon black usually used in TiC synthesis by the CBC method was replaced with graphite powder. The mechanism by which the concentration of impurity oxygen in TiC increases at low combustions speeds is studied. As the combustion speed decreases, the time which titanium particles spend in the heated zone of the combustion wave increases. Therefore, the titanium particles dissolve additional oxygen. The layer of combustion product on the surface of the particles partially 'blocks' the dissolved oxygen. The more oxygen which has dissolved in the particles of titanium in the heated zone, the more oxygen remains in the titanium carbide. Figures 6; references 7: all Russian. [100-6508]

### DISSOLUTION OF METAL OXIDE FILM IN THE PROCESS OF SYNTHESIS OF TITANIUM CARBIDE

Novosibirsk FIZIKA GORENIYA I VZRYVA in Russian Vol 20, No 6, Nov-Dec 84  
(manuscript received 1 Jul 83) pp 87-90

BLOSHENKO, V. N., BOKYY, V. A. and BOROVINSKAYA, I. P., Chernogolovka

[Abstract] Based on results of vacuum annealing of specimens consisting of a mixture of Ti + C, the possibility is shown of dissolving the oxide film on titanium in the titanium particles themselves during the time the particles spend in the area heated by a combustion wave. The experiments utilized type PTS titanium powder with particle size less than 40  $\mu\text{m}$ . Graphite powder with the same particle size was obtained by grinding rods of spectrally pure graphite and subsequent screening. A stoichiometric mixture of Ti + C was pressed into 5-8 x 20-25 mm tablets. Experiments were performed under a vacuum of  $10^{-5}$  mmHg. The mechanism of redistribution of impurity oxygen in

the area heated by the combustion wave in a Ti + C system is studied. The time spent by particles in the heated zone is about  $10^{-2}$  s, two orders of magnitude greater than the time of dissolution of the oxide film at  $800^{\circ}\text{C}$ . It is concluded that as the temperature of the oxide film rises, it is dissolved and the impurity oxygen is homogenized in the volume of the particles. The metal particles then melt and a liquid Ti + O solution is formed. Figures 4; references 11: all Russian.  
[100-6508]

UDC 669.34'295

TECHNOLOGY OF PRODUCTION OF SEMIFINISHED GOODS FROM TITANIUM NICKELIDE  
BASED ALLOYS WITH SHAPE MEMORY EFFECT

Moscow TSVETNYYE METALLY in Russian No 2, Feb 85 pp 59-61

ANOSHKIN, N. F., BOCHVAR, G. A. and FATKULLINA, L. P.

[Abstract] Semifinished goods are presently manufactured from ingots based on titanium nickelide with shape memory effect appearing at various temperatures. The thermomechanical parameters of manufacture of these goods of alloys of varying compositions were studied. The structure of the cast material is found to have a matrix of TiNi with segregations of  $\text{Ti}_2\text{Ni}$  and  $\text{TiNi}_3$ , causing brittleness in the cast metal. The most difficult operation is deformation of the ingot. The optimal deformation conditions are extrusion withdrawing of not over 8 at  $970-1000^{\circ}\text{C}$ , rate not over 50 mm/s to prevent temperature rise and partial melting of grain boundaries. After hot pressure working, goods are milled, sandblasted or shot blasted or chemically etched to remove oxides and surface defects. Work on improving the quality of semifinished products and decreasing their cost by increasing productivity of labor and improving technology is now proceeding. Figures 4; references 10: all Russian.  
[117-6508]

ABSORPTION AND DIFFUSION OF HYDROGEN IN METALS AND ALLOYS UPON ELECTROCHEMICAL  
TREATMENT

Kishinev ELEKTRONNAYA OBRABOTKA MATERIALOV in Russian No 4, Jul-Aug 84  
(manuscript received 11 Feb 83) pp 8-10

BELOBRAGIN, Yu. A., Tula

[Abstract] The process of diffusion saturation of the surface of a part with hydrogen during electrochemical treatment is described. Assuming that the rate of supply of atomic hydrogen is constant over time, an equation is derived for the distribution of concentration in the surface layer. Calculations show that the time of existence of hydrogenated layers formed by electrochemical treatment of titanium alloys is not over a few days. The minimum

part thickness for which hydrogenation does not increase the hydrogen concentration above the permissible level is about 0.2 mm. The presence or absence of hydrogen-containing compounds in a passivating film explains the contradictory experimental data concerning hydrogenation of hydride-forming metals during electrochemical treatment. References 8: all Russian.  
[007-6508]

UDC 621.9.048

TRIBOTECHNICAL FEATURES OF ELECTRIC SPARK COATINGS BASED ON TITANIUM  
DIBORIDE

Kiev POROSHKOVAYA METALLURGIYA in Russian No 5, May 85  
(manuscript received 18 May 84) pp 86-88

POLOTAY, V. V., VERKHOTUROV, A. D., PODCHERNYAYEVA, I. A., YEGOROV, F. F.  
and CHIPLIK, V. N., Institute of Chemistry, Far-Eastern Scientific Center,  
USSR Academy of Sciences

[Abstract] Key features of electric spark coatings used for hardening cutting tools and stamping equipment are durability and the friction coefficient, but little study of tribotechnical effects has been made, partially because of methodological problems related to the extremely thin coatings of these materials that have been produced. The present article reports on study of steel 45 after electro-erosional hardening (EEH) with  $TiB_2$ -Mo alloys containing 5-50% molybdenum. Results were compared to those when VK6 and T15K6 alloys were used. Friction tests were conducted with austenite rollers with an aqueous solution of silicon carbide as a lubricant. Details of coating application, X-ray analysis and friction coefficient measurement are summarized. Chemical reactions of refractory metals are known to be suppressed when they are used in alloys, and this was considered in the results. Tests showed that at elevated temperatures, the highest wear resistance was found in a hardened layer of balanced hard and plastic phases; higher amounts of solid phase components brought brittle failure, while excessive amounts of the plastic phase led to drag in the friction surfaces. References 7: all Russian.  
[185-12131]

UDC 621.762:669.295:534.282

BUFFERING PROPERTIES OF POROUS TITANIUM AND PSEUDOALLOYS BASED ON IT

Kiev POROSHKOVAYA METALLURGIYA in Russian No 5, May 85  
(manuscript received 24 Apr 84) pp 81-85

TUCHINSKIY, L. I., SHARAPOV, V. G., KHILCHEVSKIY, V. V., SAPOZHNIKOVA, A. B.  
and YENEVICH, V. G., Institute for Problems of Material Studies, UkSSR  
Academy of Sciences

[Abstract] Pseudoalloys based on titanium containing easily melted metals are intended for friction applications where durability depends on the vibration absorption properties and resistance to corrosion of the materials. The present article reports on internal friction in compositions made up of

titanium alloys containing lead, tin, eutectic bismuth alloys and ML5 magnesium alloy. Dimensions and quantity of pores, morphology, concentration and properties of additive metals and the time of saturation were assessed for their impact on energy dispersion. Electrolytic PTES and PTEM titanium powder of  $-0.63-+0.18$  mm, for the first, and  $-0.18-+0.04$  mm for the second, were saturated for 20 min. or 2 hours, then tested by tension. Results showed that the greater the porosity, the greater the damping of oscillations. All tested alloys had high buffering capacity, and that property increased as the amount of alloying metal was increased. The soft microstructure of the pseudoalloy was regarded as the cause of buffering, but the role of microplastic deformation of the titanium carcass near pores was also important. Internal friction in the alloys grew as the size of Ti particles increased. A slight reduction in buffering came with the longer period of saturation, apparently due to dissolution of the titanium into a thin intermetallide layer. Figures 4; references 10: all Russian.  
[185-12131]

UDC 669.295

#### EVALUATION OF QUALITY OF TITANIUM TETRACHLORIDE

Moscow TSVETNYYE METALLY in Russian No 6, Jun 85 pp 65-66

CHEREPANOVA, Ye. A., GUREVICH, L. M. and BERDNIKOVA, L. M.

[Abstract] The purity of titanium is largely dependent on that of initial materials such as titanium tetrachloride, which may require both chemical and suspended impurities. The authors tested the supposed impact of impurities such as Zr, Fe, Mo, Sn and V in manufacturing porous titanium for further applications. Analysis was conducted through a flow-through cuvette for a period of 7 months. Wide variations in impurities (from 0-350 particles per  $\text{cm}^3$ ) resulted in unstable products and uncertain results in further manufacturing processes. For these reasons, constant monitoring of the purity of  $\text{TiCl}_4$  should be sought, in order to obtain the most consistent product. Figures 2.  
[204-12131]

## TRANSFORMATION AND STRUCTURE

UDC 669.018.2

### ROLE OF OPTIMIZATION OF HETEROGENEITY IN PREPARING ULTRA-FINE-GRAINED STRUCTURE OF SUPERPLASTIC ALLOYS

Ordzhonikidze IZVESTIYA VYSSHIKH UCHEBNIKH ZAVEDENIY: TSVETNAYA METALLURGIYA in Russian No 1, Jan-Feb 85 (manuscript received 19 Apr 84) pp 93-107

PORTNOY, V. K., Department of Study of Nonferrous, Rare and Radioactive Metals, Moscow Steel and Alloy Institute

[Abstract] Micro-fine-grained superplasticity in alloys at high homologous temperatures and low deformation rates, related to granular creep and plate shift, has been accomplished by various processes. The present article summarizes studies of such matrix changes during deformation for alloys such as Al-6%, Cu-0.5%, at cooling rates above 70° K/sec. and subsequent annealing at 370°C. Optimization of structural heterogeneity at various stages of the technical chain are discussed for various other alloys as well. The eutectic Al-5%Zn-5%Ca alloy with dual eutectic crystallization contained more than 20% by volume of excess  $Al_3ZnCa$ , with no variation as temperature was changed in the solid state. Ultra-fine grains formed through a combination of fragmentation and spheroidization of second-phase particles. A Zn-22%Al alloy, which formed a fine-grain structure after simple thermal processing at 350°C, and the effect of 12% cementite in U8 steel, are also discussed. In general, results indicated that varying conditions of deformation and annealing can be used to optimize the morphology of initial platelet structure and to effect fragmentation and spheroidization. Stages and results of this system are summarized. Figures 9; references 35: 25 Russian (3 translations from English), 10 Western.  
[150-12131]

UDC 539.3

### STABILITY OF TWO FIBERS IN AN ELASTIC MATRIX AT SLIGHT DEFORMATIONS

Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 21, No 1, Jan 85 (manuscript received 24 Nov 83) pp 3-10

AKBAROV, S. D. and GUZ', A. N., Institute of Mathematics and Mechanics, Azerbaijan Academy of Sciences, Baku; Institute of Mechanics, Ukrainian Academy of Sciences, Kiev

[Abstract] A complete analysis is presented of the loss of stability of two fibers in an elastic matrix considering the interaction of the fibers upon loss of stability at small, subcritical deformations. An infinite elastic



body is studied, reinforced with two straight fibers under compression along the fibers, assuming that the fibers are of identical material. Only the second version of the theory of small subcritical deformations is analyzed, in which the major subcritical stress state is determined by a geometrically linear theory. It is concluded that at high rigidity ratios the mutual influence of fibers upon loss of stability can be ignored. The neighboring fiber has a reinforcing influence only upon redistribution of the subcritical stress state, in that when a second fiber is present the concentration of filler increases, which decreases the normal stress value. Figures 4; references 18: all Russian.

[108-6508]

UDC 539.3

#### DETERMINATION OF ELASTIC PROPERTIES OF POROUS MATERIAL

Kiev DOKLADY AKADEMII NAUK UKRAINSKOY SSR. SERIYA A. FIZIKO-MATEMATICHESKIYE I TEKHNICHESKIYE NAUKI in Russian No 1, Jan 85  
(manuscript received 29 Nov 83) pp 69-74

GOLOVCHAN, B. T. and KUSH, V. I., Institute of Superhard Materials,  
Ukrainian Academy of Sciences, Kiev

[Abstract] A method is suggested for determining the elastic characteristics of porous materials based on strict solution of the boundary value problem of the theory of elasticity. The model of a pore space studied is an elastic isotropic medium with spherical cavities whose centers form a three-dimensional orthogonal lattice. The method allows calculation of the stress-strain state of a porous medium under the influence of an external load, the nature of which determines the elements of the matrix included in the right portion of an infinite system of equations. The solution presented is sufficient to determine the tensor of effective elastic characteristics of the porous medium. The rigorous approach suggested for determination of the elastic characteristics of the porous material allows the limits of applicability of approximate solutions to be determined and can be used for materials with arbitrary porosity in the case of isolated pores of near-spherical shape. References 8: 6 Russian, 2 Western.

[98-6508]

PROJECTION OF SOLIDUS SURFACE AND REACTION UPON CRYSTALLIZATION OF  
Ru-ZrRu-ZrIr-Ir SYSTEM ALLOYS

Kiev DOKLADY AKADEMII NAUK UKRAINSKOY SSR. SERIYA A. FIZIKO-MATEMATICHESKIYE  
I TEKHNICHESKIYE NAUKI in Russian No 1, Jan 85 (manuscript received 10 Sep 84)  
pp 75-78

YEREMENKO, V. N., Academician, Ukrainian Academy of Sciences, KHORUZHAYA, V.G.,  
and SHTEPA, T. D., Institute of Materials Science, Ukrainian Academy of  
Sciences, Kiev

[Abstract] A study is made of the structure of the solidus surface of the  
system Ru-ZrRu-ZrIr-Ir and reactions occurring upon crystallization of alloys  
in the system. The alloys used in the study were prepared by arc melting of  
iodide zirconium and preliminarily remelted powders of ruthenium and iridium,  
purity 99.97%. Studies were performed on cast, homogenized and annealed  
specimens by metallographic and x-ray phase analysis. The system is found to  
contain no ternary compounds. The processes in the system occur at tempera-  
tures decreasing from the binary system Zr-Ir to the system Zr-Ru. Ruthenium  
and iridium are highly soluble in intermediate phase. Figures 3;  
references 5: 3 Russian, 2 Western.  
[98-6508]

REGULARITIES OF STRUCTURE FORMATION UPON GRAPHITIZATION OF MIXED ALLOYS

Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA  
in Russian No 1, Jan 85 (manuscript received 15 Aug 84) pp 97-101

SEMENOVA, I. O. and MOVCHAN, V. I., Dnepropetrovsk Metallurgical Institute

[Abstract] A study is made of the regularities of structure formation in  
the process of graphitization of nickel steel containing 1.0% C and 15% Ni  
(type 10M15). Graphitization of the cast steel was performed in the 500-750°C  
temperature interval. Annealing at 500°C causes graphite to be segregated  
in the austenite far from the martensite sectors. The carbon-poor austenite  
undergoes additional martensite conversion upon cooling from the graphitiza-  
tion temperature. Graphitizing annealing leads to the formation of the struc-  
ture consisting of austenite, graphite, areas of initial primary martensite  
with dispersed segregations of globular cementite. Graphitization at 750°C  
results in separation of graphite only at points of former martensite plates,  
with no graphite in the austenite. In order to increase uniform distribution  
of graphite within the matrix in both austenite and martensite it is recom-  
mended that graphitizing annealing be performed in the 600-650°C temperature  
range. Figures 2; references 2: 1 Russian, 1 Western.  
[125-6508]

PHASE TRANSITIONS AND FEATURES OF PHYSICAL PROPERTIES IN SYSTEM OF NON-  
ISOSTRUCTURAL SODIUM-LITHIUM-CADMIUM NIOBATES

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 55, No 3, Mar 85  
(manuscript received 18 Jun 84) pp 601-606

FESENKO, Ye. G., REZNICHENKO, L. A., IVANOVA, L. S., RAZUMOVSKAYA, O. N.,  
DANTSIGER, A. Ya., SHILKINA, L. A. and DERGUNOVA, N. V., Scientific Research  
Institute for Physics, State University of Rostov on the Don

[Abstract] Formation of solid solutions based in part on sodium niobates with non-isostructural components offer new possibilities for application. The present article reports on study of perovskite ( $\text{NaNbO}_3$ ), pseudoilmeneite ( $\text{LiNbO}_3$ ) and columbite ( $\text{CdNb}_2\text{O}_6$ ) used to produce sodium-lithium-cadmium niobate systems. The systems were studied in 6 cross-sections corresponding to 5-20%  $\text{CdNb}_2\text{O}_6$  by molecular weight. The breadth of monotropic zones in the systems exceeded those of various MO systems. X-ray photos of the solid solutions studied showed structural elements that were in inverse relationship to temperature; this was related to structural features of the small  $\text{Na}^{1+}$ ,  $\text{Li}^{1+}$  and  $\text{Cd}^{2+}$  ions. Patterns of changes in electrophysical properties of the solid solutions during restructuring during the monotropic transition were studied in the vicinity and within the biphasic balance. The dielectric, piezoelectric, physical, elastic and segnetoelectric properties of the materials are discussed. Heating to  $623^\circ\text{K}$  produced significant depolarization of the samples. The test materials are useful for a wide variety of transformers and other applications. Figures 6; references 11: 7 Russian, 4 Western.  
[161-12131]

UDC 669.85/86.018:538.662.13:620.186.1

THERMOMAGNETIC ANALYSIS OF PROCESSES LEADING TO HIGH COERCIVITY STATE OF  
ALLOYS  $\text{Sm}(\text{Co}, \text{Cu})_6$  and  $\text{Sm}(\text{Co}, \text{Cu}, \text{Fe}, \text{Zr})_{7.4}$

Sverdlovsk FIZIKA METALLOV I METALLOVEDENIYE in Russian Vol 59, No 1,  
Jan 85 (manuscript received 29 Mar 84) pp 47-55

KHRABROV, V. I., SHUR, Ya. S., POPOV, A. G. and GAVIKO, V. S., Institute of  
Metal Physics, Ukrainian Scientific Center, Academy of Sciences USSR

[Abstract] In spite of recent successes in the study of the microstructure of permanent magnets, such important problems as redistribution of elements among phases upon decay and heat treatment, relationship of  $H_c$  to microstructure, composition and magnetic characteristics of phases have received little study. This work analyzes some of these questions on the basis of data on the influence of temperature and time of tempering on magnetization, Curie point  $T_c$  and  $H_c$  of alloys  $\text{Sm}(\text{Co}_{0.65}\text{Cu}_{0.35})_6$ ,  $\text{Sm}(\text{Co}_{0.66}\text{Cu}_{0.1}\text{Fe}_{0.021}\text{Zr}_{0.026})_{7.4}$  and permanent magnets made of the latter alloy. The alloys were

produced by induction melting in alundum crucibles in an atmosphere of argon. Upon isothermal decomposition of solid solutions of the dispersion-hardened alloys, redistribution of chemical elements among phases ends in the initial stage of decomposition. During heat treatment the composition of the phases changes primarily by diffusion of Cu from the 2:17 phase into the 1:5 phase, CO in the opposite direction. Correlation between  $H_c$  and Curie points of the 1:5 and 2:17 phases during tempering indicates that  $H_c$  is determined basically by the gradient of the exchange interaction parameter. In the high coercivity state the phases differ greatly in magnetic properties, phase 1:5 being slightly magnetic with a low  $T_c$ , phase 2:17 being highly magnetic with high  $T_c$ . Figures 8; references 17: 10 Russian, 7 Western.

[121-6508]

UDC (669.14+666.71)539.319

#### DEPENDENCE OF FATIGUE STRIATION STEP ON RANGE OF COEFFICIENT OF STRESS INTENSITY

Kiev FIZIKO-KHIMICHESKAYA MEKHANIKA MATERIALOV in Russian Vol 21, No 2, Mar-Apr 85 (manuscript received 27 Jun 83) pp 46-55

BOTVINA, L. R. and LIMAR', L. V.

[Abstract] Quantitative macrofractography has recently been used to determine the connections between fracture relief features and the parameters of loading and characteristics of failure mechanisms. The most informative features of microrelief are fatigue striations, which make it possible to assess the life of a machine part at the stage of crack development observed. The present article presents calculations of the fatigue striation step in order to determine the coincidence interval of macrorates of fatigue cracking in relation to microrates. Limitations on this rate for steels and aluminum, titanium and magnesium alloys are presented. At rapid rates of cracking, divergences are related to static failure mechanisms such as pitting, scaling and intergranular failure. Replicated fatigue striation steps were produced in vacuum or inert media. The striation step may also diverge from crack progression because of the lack of a new surface formation, as observed in steel with a ferrite-perlite structure. Several factors relate striation to plastic deformation of test materials at the crack surface, including the plastic component which appears only in intermediate fatigue cracks, the morphology of construction materials showing cyclic scaling and a shifted microrelief, pitting, granular plastic deformations, shift failures near the surface and other plastic flow characteristics. Thus a high degree of coincidence between macro- and micro-rates of fatigue cracking was found in a narrow range of  $10^{-6}$ - $10^{-7}$  m/cycle. At lower rates striation formation required plastic viscosity in the material that did not appear until higher rates, while at high rates, failure was tied to static mechanisms. References 64: 25 Russian, 39 Western.

[174-12131]

## HOMOGENIZATION OF ALLOYS OF MULTICOMPONENT SYSTEM UNDER WEIGHTLESS CONDITIONS

Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA in Russian Vol 49, No 4, Apr 85 pp 667-672

GEL'FGAT, Yu. M. and GORBUNOV, L. A.

[Abstract] Multicomponent monocrystalline alloys and composition materials with high homogeneity require preliminary homogenization in ampules. The present article reports on study of the possibility of forced homogenization using internally generated electromagnetic forces. Considering that electrical conductivity in most compositions, including semiconductors, is of the order of  $10^6 \text{ Ohm}^{-1} \cdot \text{m}^{-1}$ , magnetohydrodynamic (MHD) action in the alloy was assessed for three variants. In the first, forced homogenization was based on a rotating magnetic field; in the second, a linear cylindrical inductor was used, and the third version combined these two. Effectiveness was tested on tin-bismuth and tin-lead systems in quartz ampules, and effects registered with a vortex electromagnetic sensing device. Results showed that the electromagnetic action greatly speeded homogenization. Best effects were received using the third mixing variant, with rotating field and cylindrical magnetic inductor positioned at right angles to each other. The procedure is recommended for cosmic technical implementation where high purity precludes use of mixing devices of other kinds. Figures 4; references 9: all Russian.  
[178-12131]

UDC 669.15'24'25'295:669.112.227.346:539.89

SPECIFICS OF HIGH PRESSURE ON  $\alpha \rightarrow \gamma$  TRANSFORMATION IN Fe-Ni-Co-Ti ALLOY

Sverdlovsk FIZIKA METALLOV I METALLOVEDENIYE in Russian Vol 58, No 6, Dec 84 (manuscript received 13 Apr 84) pp 1121-1124

GUN'KO, L. P., YERMAKOV, V. M. and KOKORIN, V. V., Institute of Metal Physics, Ukrainian Academy of Sciences

[Abstract] A study is presented of the specifics of influence of external hydrostatic pressure on  $\alpha \rightarrow \gamma$  transformation in Fe-Ni-Co-Ti alloy with 23.8 weight % Ni, 10.5 weight % Co and 8.26 weight % Ti, which differs from other iron-based alloys in that the  $\gamma \leftrightarrow \alpha$  transformation is practically thermoelastic. The alloy was melted in an arc furnace in an atmosphere of argon, hardened from 1423°K in water and specimens cut from castings were deformed by compression on a hydraulic press with subsequent homogenization at 1373-1473°C for 1 hour and quenching in water. The nature of the  $\gamma \leftrightarrow \alpha$  conversions of the alloy after homogenizing treatment and aging was studied at atmospheric pressure by low field magnetic susceptibility method. The structure of specimens before and after quasihydrostatic compression was studied with an optical microscope, using electrically polished sections. It was found that the  $\alpha \rightarrow \gamma$  transformation under pressure in the Fe-Ni-Co-Ti system occurs by a mechanism

differing from that observed in binary Fe-Ni alloys. The application of pressure together with the obvious effect of decreasing the  $\gamma \rightarrow \alpha$  transformation temperature preserves the  $\alpha \rightarrow \gamma$  transformation mechanism observed in Fe-Ni-Co-Ti upon heating. In this case, and under pressure at room temperature, the martensite is converted to austenite by reverse displacement of the interphase boundary. Figures 4; references 4: 3 Russian, 1 Western.  
[85-6508]

UDC 621.365.91:537.533'621.187.1.539.2+620.17'001.5

#### STRUCTURE AND PROPERTIES OF POROUS Ni-Al<sub>2</sub>O<sub>3</sub> VACUUM CONDENSATES

Moscow FIZIKA I KHIMIYA OBRABOTKI MATERIALOV in Russian No 6, Nov-Dec 84  
(manuscript received 10 Jun 84) pp 92-96

MOVCHAN, B. A., GRECHANYUK, N. I. and MUSHEGYAN, V. O., Kiev

[Abstract] A study is made of the structure and properties of condensates in the system Ni-Al<sub>2</sub>O<sub>3</sub> obtained by creation of a "shading" effect using dispersed refractory particles with simultaneous separate precipitation of metallic and nonmetallic materials. The mixed vapor flow was condensed onto a substrate of type 3 steel at 700, 900 or 1000°C. The condensation rate of Ni and Al<sub>2</sub>O<sub>3</sub> was 0.4-0.5 and 0.1-0.2  $\mu\text{m/s}$ , respectively. The structure was studied metallographically, and total and open porosity and mean pore diameter were determined. Mechanical properties were estimated by bend testing. Pore volume and dimensions could be regulated in the condensate by changing the concentration of the phases, substrate temperature or both. The strength of the condensed two-phase materials decreased with increasing porosity. Figures 5; references 9: all Russian.  
[51-6508]

UDC 539.43:620.17

#### POSSIBLE DISRUPTION OF INVARIANCE OF KINETIC FATIGUE FRACTURE DIAGRAMS CAUSED BY CRACK CLOSURE

Kiev FIZIKO-KHIMICHESKAYA MEKHANIKA MATERIALOV in Russian Vol 20, No 6, Nov-Dec 84 (manuscript received 28 Sep 83) pp 25-29

ROMANIV, O. N., TKACH, A. N. and LENETS, Yu. N., Institute of Physico Mechanics imeni G. V. Karpenko, Ukrainian Academy of Sciences, L'vov

[Abstract] In spite of a large number of works published to date on analysis and quantitative estimation of the influence of crack closure on cyclical fatigue strength of materials, there is as yet no reliable information on conditions of realization of any given mechanism of crack closure or the degree of its influence on the kinetics of fatigue crack formation. The results of studies of fractures in zones of contact of fatigue crack walls are quite limited and nonsystematic. The purpose of this work is further development of concepts concerning the nature of the phenomenon of crack

closure and its influence on the growth of fatigue cracks. Tests were performed on type 10GN2MFA steel quenched in water from 920°C and tempered at 650°C for 19 hours. Fatigue testing was performed by rigid loading of prismatic specimens with an edge crack in cantilever flexure at 15 Hz in an atmosphere of laboratory air at 19-22°C, relative humidity 40-60%. The results presented form the basis for a number of recommendations concerning methods of testing and interpretation of experimental fatigue test data. Rigid requirements must be met as to rate of decrease of  $\Delta K$  in threshold determinations; parameter  $\Delta K_{th}$  cannot be correctly determined without the use of corrections considering the curvature of the crack leading edge and the change in the value of  $\Delta K_{eff}$  across the leading edge. This change can be quite significant in estimating the influence of the scale factor on  $\Delta K_{th}$ . Figures 4; references 18: 3 Russian. 15 Western.  
[86-6508]

UDC 629.12+530.135.7

#### NATURE OF STRENGTH OF METALS AND CERMETS

Kiev PROBLEMY PROCHNOSTI in Russian No 9, Sep 84 (manuscript received 2 Apr 84)  
pp 108-109

KUZ'MENKO, G. I. and NIKIFOROV, A. I., Odessa Institute of Maritime Fleet Engineers

[Abstract] The problem of increasing the strength of materials through attainment of a sufficiently fine grain structure is examined from the standpoint of dislocation theory and the Griffiths theory relating strength to microhardness. Such an approach allows unified treatment of metals and cermets in the analysis of the crystallization process, very desirable where substitution of cermets for metals such as structural steel is contemplated. This approach has also been coordinated with quantum-wave methods of analysis. Data on the relation between the diffusion coefficient  $Lv$  ( $L$  - dimension of crystallite,  $v$  - velocity of atom transfer), the atom mass, and the Planck constant in an aluminum-copper alloy melt at various concentrations and cooling rates indicate that a crystallite should be treated as a diffusional wave-mechanical entity rather than a quantum. According to the theory of Markov processes, it can be described by a diffusion wave analogous to a deBroglie quantum wave. While atomic laws remain applicable here, it then becomes possible to comprehensively evaluate the pressure dependence of structural characteristics. This is particularly pertinent to superhigh-pressure pulverization and sintering technologies. This should lead to development of new high-strength cermets, especially nitrides and silicates, producible under pressure up to  $10^{11}$  Pa. References 5: all Russian.  
[29-2415]

## EFFECT OF ULTRA-HIGHSPEED CRYSTALLIZATION ON STRUCTURE OF Ni-Ti-Si and Ni-Ti-Cu ALLOYS

Moscow IZVESTIYA AKADEMII NAUK SSSR: METALLY in Russian No 5, Sep-Oct 84  
(manuscript received 3 Aug 83) pp 143-146

ZAKHAROVA, M. I., KHUNDZHUA, A. F., OSIPOV, E. K. and KOVNERISTYY, Yu. K.,  
Moscow

[Abstract] Titanium nickelide has such unique properties as shape memory, high durability and corrosion resistance. The present article reports on ultra-highspeed crystallization (UHC) at  $10^5$ - $10^8$  S/sec [S-unknown] to determine possibilities of increasing the dissolution of copper and silicon in titanium nickelide and structural transformations in such alloys. Blends were 51Ni+45Ti+4Si and 46Ni+46Ti+8Cu. Samples were prepared in an arc furnace with an argon medium, using highly purified metals. Use of crucible-free melting and cylinder surface casting promoted rapid foil production of refractory and chemically active metals and alloys. The two-phase nature of the Ni-Ti-Si alloy produced from a solid state is discussed. Diffraction electron microscopy confirmed the two-phase structure of both alloys, and showed that particles of the X-phase had ellipsoid form and balanced distribution inside the granules of the beta-matrix. A meta-stable state of the single-phase solid solution was found. Defect structure varied for alloys treated by ultra-highspeed crystallization and those tempered from solid states. Figures 4; references 10: 6 Russian, 4 Western.  
[66-12131]

## DIFFUSIONAL PERMEABILITY OF INTERFACE BOUNDARIES IN EUTECTIC ALLOY MELT-GROWN BY METHOD OF ORIENTED CRYSTALLIZATION

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 280, No 3, Jan 85  
(manuscript received 30 Jun 84) pp 613-615

BOKSHTEYN, S. Z., VASILENOK, L. V. and S. T. KISHKIN, S. T., Academician

[Abstract] A metallographic study of the eutectic cobalt alloy with reinforcing TaC fibers was made, for the purpose of determining the diffusional permeability of interface boundaries on which the structural stability of that alloy largely depends. Specimens of polycrystalline alloy with grain orientation were melt-grown by the method of oriented crystallization and then sliced transversely. Radioactive nickel  $^{63}\text{Ni}$  was deposited on the surface for subsequent diffusion annealing in a vacuum furnace at  $900^\circ\text{C}$  for 40 h. The specimens were then shaved mechanically or by electropolishing so as to expose the most radioactive layer. This one was examined both by high-resolution autoradiography and under an electron microscope, thin foils for the latter having been prepared by electropolishing with an electrolyte consisting



of 125 cm<sup>3</sup> methyl alcohol + 75 cm<sup>3</sup> butyl alcohol + 12.5 cm<sup>3</sup> perchloric acid at -10°C. The results reveal differences in the permeability of different inter-phase boundaries, namely preferential diffusion through one boundary and no advance diffusion through some other boundaries. An analysis of interface coupling based on the "lattice of congruent nodes" model and supported by electron diffractograms confirms the authors' hypothesis of orientation-dependent diffusional permeability. Figures 1; references 4: 2 Russian, 2 Western.  
[87-2415]

UDC 669.295.24.539.370

#### STRUCTURAL PHASE CONVERSIONS AND PROPERTIES OF THE ALLOYS NiTi and NiTiFe

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 277, No 6, Aug 84  
(manuscript received 25 Oct 83) pp 1388-1391

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Institute of Metal Physics, Ural Science Center, USSR Academy of Sciences  
Sverdlovsk; Siberian Institute of Physics and Technology, Tomsk

[Abstract] A detailed study is presented of the structure and properties of the alloys Ni - 49.0% Ti, Ni - 48.7% Ti, Ni - 50% Ti - 1% Fe, Ni - 50% Ti - 2% Fe (in atomic %) over a broad temperature range. The studies were performed by electron microscopy, microdiffraction of electrons and x-ray diffractometry. Resistivity  $\rho$ , shear modulus  $G$  and mechanical properties were also determined. The results indicate that in Ni-Ti based alloys the initial structure upon cooling is unstable with respect to the two martensite transformations  $B2 \rightarrow R$  and  $B2 \rightarrow B19$ , while the intermediate shear structure is a precursor of the martensite phases. The sequence of structural transformations in the alloy is diagrammed. Figures 4; references 11: 8 Russian, 3 Western.  
[012-6508]

UDC 669.11.224:546.261

#### STRUCTURE AND DUCTILITY OF IRON-CARBON EUTECTIC ALLOYS

Moscow METALLOVEDENIYE I TERMICHEKSKAYA OBRABOTKA METALLOV in Russian No 9,  
Sep 84 pp 5-9

NIZHNIKOVSKAYA, P. F.

[Abstract] A basically new solution is found to the problem of increasing the ductility of white cast iron, allowing it to be deformed by an economical method, rolling of an ingot or cast blank at speeds normal for metallurgical production practice. The method is based on the use of carbide transformations occurring in eutectic carbides upon heat and deformation treatment. The structural changes are studied in iron-carbon alloys containing carbide-forming elements in a quantity such that they are primarily included in the cementite lattice forming the solid solution. The increase in ductility of

the cementite observed currently is related to weakening of barriers to the movement of dislocations. Ductility of eutectic iron-carbon alloys is determined by the structure of the eutectic carbides and can be increased by formation during preliminary heat treatment of dislocations in the eutectic carbides and creation of subgrain boundaries on which the carbides are fragmented during deformation, or by greatly increasing the ductility of the carbides by transformations occurring under the influence of deformations. References 10: 8 Russian, 2 Western.

[011-6508]

UDC 620.186:669.1'784'71

#### CRYSTALLIZATION AND PRIMARY STRUCTURE OF Fe-C-Al-ALLOYS

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 9, Sep 84 pp 10-11

YATSENKO, A. I., REPINA, N. I., DORONKIN, K. Yu., Institute of Ferrous Metallurgy, Dnepropetrovsk

[Abstract] Specimens with a mass of 200 g were cooled in the crystallization interval of 0.5°C/s, then hardened in an alkaline solution to fix morphologic and concentration specifics of the primary structure. Charges with a mass of 1 g were taken from these samples and melted in sealed quartz ampules, then hardened with continuous cooling or after isothermal holding at various temperatures in the crystallization interval. Differential thermal analysis was performed on the same specimens at heating and cooling rates of 1.3°C/s. It was found that the primary structure of alloys based on  $\alpha$  and  $\gamma$  solid solutions is formed by dendritic crystallization. The formation of peritectic  $\gamma$  and  $\epsilon$  phases occurs on the basis of the primary dendrites by rim growth. Intracrystalline liquation of aluminum may be direct or reverse, depending on the composition of the alloys. References 6: 4 Russian, 2 Western.

[011-6508]

UDC 669.017.3

#### FORMATION OF EUTECTIC STRUCTURES IN BINARY METAL SYSTEM ALLOYS

Minsk VESTSI AKADEMII NAUK BSSR in Russian No 1, Jan-Mar 85  
(manuscript received 31 May 84) pp 32-34

PARKHUTIK, P. A., Physico-Technical Institute, Belorussian Academy of Sciences

[Abstract] A proof is presented of the presence of a contact between two primary crystals as the center of formation of a eutectic colony. The microstructure of a pure eutectic Al-Zn alloy was studied. Crystals of the more refractory leading phase, an alpha-solid solution of zinc in aluminum, are formed in the eutectic melt first. The liquid around them is enriched in the secondary component, zinc, as a result of which neighboring crystals based on it are formed. The interface between the two pseudoprimary crystals is the locus of formation and subsequent development of the eutectic colonies. Figures 2; references 10: 4 Russian, 6 Western.

[166-6508]

## ANOMALOUS EXTRUSION OF METALS IN ULTRATHIN CHANNELS

Leningrad PIS'MA V ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 11, No 6,  
26 Mar 85 (manuscript received 22 Jan 85) pp 371-374

BOGOMOLOV, V. N., ZHURAVLEV, V. V., ZADOROZHNIY, A. I. and FOKIN, A. V.,  
Physicotechnical Institute imeni A. F. Ioffe, USSR Academy of Sciences,  
Leningrad

[Abstract] The authors found that in material such as porous glass where the radius of pores is 20 to 45 Å, pore length about 0.2 cm at pressures of less than 10 kbar, metals penetrate the entire depth of the channels at temperatures below their melting points, i.e., in the solid phase. The reason for the phenomenon is that the metal at first penetrates into the channel to a depth approximately equal to the channel radius, then due to the great curvature of the surface of the metal in the channels the melting point of the metal drops, the metal becomes liquid and extrusion continues. An equation is presented to describe the decrease in melting point as a function of radius for spherical particles. Extrusion with capillary melting satisfactorily explains a number of experimental puzzles. It can be used for the production of ultrathin metal filaments. Figures 2; references 3: all Russian.  
[158-6508]

UDC 546.832

## PHASE COMPOSITION AND STRUCTURAL SPECIFICS OF VACUUM HAFNIUM DIOXIDE CONDENSATES

Kiev DOKLADY AKADEMII NAUK UKRAINSKOY SSR. SERIYA A. FIZIKO-  
MATEMATICHESKIYE I TEKHNICHESKIYE NAUKI in Russian No 3, Mar 85 (manu-  
script received 29 Jun 84) pp 78-80

BATALIN, G. I., KACHUR, A. V., KUSHKOV, V. D. and MEL'NIKOV, A. V.,  
Kiev State University

[Abstract] Results are presented from a study of hafnium dioxide vacuum condensates. Vacuum condensate specimens were obtained by electron beam melting in a vacuum of  $10^{-3}$  Pa of type GFO-1 hafnium dioxide. The vapor phase was condensed at  $35 \text{ nm} \cdot \text{s}^{-1}$  on polycrystalline molybdenum substrates, along which a temperature gradient of 650-1350°C was created. The vacuum condensates produced were studied on an x-ray diffractometer, establishing that only monoclinic  $\text{HfO}_2$  was formed. A second structural zone appears in the 650-1100°C substrate temperature interval, with primary orientation of crystallites relative to the plane of the substrate. Figures 2; references 7: 4 Russian, 3 Western.  
[159-6508]

## VITREOUS STRUCTURES IN METAL ALLOYS IRRADIATED BY HIGH-ENERGY BEAMS

Moscow P<sub>O</sub>VERKHNOST: FIZIKA, KHIMIYA, MEKHANIKA in Russian No 6, Jun 85  
(manuscript received 21 May 83, final version received 19 Mar 84) pp 5-16

ILIN, A. I. and KRAPOSHIN, V. S., Chernogolovka

[Abstract] Quenching metal alloys from a melt at rates of  $10^3$ - $10^8$  K/s can produce a broad range of metastable states capable of existing at room temperature. Vitreous (amorphous) structures produced in this manner are of particular practical interest now, supersaturated solid solutions and intermediate phase having already been used for some time. Vitreous structures in iron alloys such as 30KhGSN2A and ShKh15 steels have been produced by quenching after melting with a periodic-pulse CO<sub>2</sub>-laser beam. The two experimentally established facts, namely a change in the shear viscosity during solidification of the vitreous melt and a relative shifting of the maxima of the radial distribution function, were interpreted using the model of random close packing. This model has certain limitations, however. The large change in shear viscosity by 10-15 orders of magnitude during glass transition within a relatively narrow temperature range of only a few tens of degrees is characteristic not only of metal alloys but also of inorganic and organic glasses. In addition, neither the similarity of diffraction patterns nor the approximately same splitting of the radial distribution peaks regardless of the alloy composition can be explained on the basis of this model. It becomes necessary to also consider structural relaxation and the splitting of many vitreous metal alloys into two vitreous phases of different chemical compositions. Among various other proposed models, formation of an ultrafine-disperse eutectic phase (Fe-Fe<sub>3</sub>C) appears to be most plausible. With this model it is possible to interpret much better the change in shear viscosity on the basis of the Newton equation of hydrodynamics for viscous fluids, the similarity of diffraction patterns on the basis of the optical coherence criterion, and the phase splitting during solidification according to the phase rule. The validity of this model needs to be further confirmed by measurements and calculations. If correct, it predicts the feasibility of producing a broad diversity of amorphous metal alloys or coatings by use of high-energy beams for melting and simultaneous controlled addition of alloying elements. The authors thank Ch. V. Kopetskiy, Ye. G. Ponyatovskiy and G. Z. Pinsker for discussions and critiques. Figures 1; references 46: 29 Russian, 17 Western (2 in Russian translation).  
[196-2415]

## FORMATION OF PERIODIC STRUCTURES ON OXIDIZING METALS UNDER IMPACT OF COHERENT LIGHT

Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA in Russian Vol 49, No 6, Jun 85 pp 1229-1232

BAZHENOV, V. V., MAKIN, V. S., RUBANOVA, G. M. and TRUBAYEV, V. V.

[Abstract] Study of surface breakdown of polished metals by laser impulse has shown the formation of a regular profile. The present article reports on study of titanium, molybdenum, and Kh18N10T stainless steel under pulsed laser irradiation of up to 30-mJ, with a pulse length of ca. 20 mcs. When stainless steel was tested, careful observation was made of the dynamics of the burning spot. A periodic relief shape was observed for the laser beam cut on the metal. As pulse frequency increased, the reverberation period increased as well, forming wave-like vectors of as much as 700-800 Å. The authors present mathematical calculations for predicting this phenomenon, which show that as the thickness of the oxide layer formed during laser cutting grew, the period of the growing relief declined. For stainless steel, changes of 400-800 Å corresponded to oxide layers of 500-1000 Å. A fine periodic relief structure was also observed on molybdenum and titanium sheets tested; the authors propose a mathematical model of the relationship between oxidation and relief formation. Recommendations are made for reducing the degree of radiation coherence, use of polarized radiation as far as possible, reduction of average microrelief surface, reduction of dielectric reflective irregularities, and suppression of the size of the surface electromagnetic wave in the air by application of fine dielectric coatings to metals before laser cutting. References 4: 2 Russian, 2 Western.

[208-12131]

## WELDING

UDC 621.791.754'293:669.15-194.56:621.039.5

### WELDING OF AUSTENITIC STEELS IRRADIATED BY NEUTRONS IN NUCLEAR REACTOR

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 5, May 85 pp 12-13

KRYLOV, Ye. A., candidate of technical sciences, and ZINKOVSKIY, V. I., engineer

[Abstract] An experimental study was made for determining the weldability of austenitic steels after irradiation by neutrons in a nuclear reactor. In the first experiment 1-mm-thick 50x50 mm plates of 12Cr18Ni10Ti steel were welded automatically in an argon arc with a refractory electrode, after they had been soaked in a stream of water with a  $3 \cdot 10^{20} \text{ cm}^{-3}$  flux of 1 + MeV neutrons at 70°C in an SM- 2 MW reactor. The results of subsequent tension tests at an elongation rate of 1 mm/min and cyclic 90° bending tests at room temperature indicate no significant effect of neutron irradiation at this level on the welding process and on the strength of joints. Evidently welding tends to anneal radiative defects in the metal layer adjacent to the seam, as confirmed by microhardness measurement. In the second experiment 0.3-mm-thick tubes, 6 mm in diameter and 180 mm long, of Cr16Ni15Mn3B steel were cut from sheaths of fuel elements in a BOR- 60 MW reactor after irradiation to a  $1 \cdot 10^{22} \text{ cm}^{-3}$  flux of 0.1 + MeV neutrons at 400-650°C. The tubes, closed at both ends with nonirradiated caps of the same steel, were then welded electrically with an 18-20 A current at 10 V under an argon shield flowing at a rate of 6-8 dm<sup>3</sup>/min while being rotated at a speed of 6-7 rpm. The results of subsequent hermeticity tests by the vacuum-liquid method and metallographic examination indicate that neutron irradiation at this level tends to increase the defectiveness of the metal layer adjacent to the seam and consequently also the proneness to intercrystalline fracture during welding. References 5: 3 Russian, 2 Western (1 in Russian translation).  
[197a-2415]

UDC 621.791.755

### INCREASING STABILITY OF ARC AND IMPROVING QUALITY OF SEAM IN HIGH-SPEED WELDING

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 5, May 85 p 38

VERBITSKIY, V. G., candidate of technical sciences, KISELEVICH, I. V., student, and ZAIKIN, P. B., student, Ufa Institute of Aviation imeni S. Ordzhonikidze

[Abstract] A laboratory plasmatron apparatus has been developed and built for experimental study of high-speed welding of 12 Cr18Ni10Ti sheet steel (0.1-0.2 mm thick), which in turn will lead to development of a welding

process with higher arc stability and better seam quality. The apparatus is designed for establishing the dependence of the arc stability on the plasma-tron tilt angle and on the intensity of a constant transversely acting external magnetic field as well as the dependence of the seam width on the welding rate under various arc stabilization modes. The results obtained so far indicate that only tilting the plasmatron for arc stabilization is effective at welding rates below 250 m/hr, with the arc being somewhat compressed and the anode spot returning close to its original position, but the seam will still be wide and of poor quality. Magnetic stabilization alone, based on interaction between the magnetic field of the arc and the constant transverse external magnetic field, results in a seam of better quality. Combined stabilization by tilting the plasmatron and applying a constant transverse magnetic field causes the most effective arc compression and minimum displacement of the anode spot so that a narrow seam of the best quality will result. This method of stabilization can also contribute to higher productivity, making it feasible to increase the welding rate from 120 to 350 m/hr.

Figures 4; references 2: both Russian.

[197a-2415]

UDC 621.791.4.539.378.3

#### PARAMETERS OF SOLID-PHASE DIFFUSION ZONE FORMED DURING WELDING OF PLATINUM TO TITANIUM

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 5, May 85 pp 39-40

DZHUR, Ye. A., candidate of technical sciences, KVASHA, A. N., candidate of technical sciences, KEDRIN, I. D., candidate of technical sciences, and FESENKO, A. G., engineer, Dnepropetrovsk State University

[Abstract] In joining together two different metals such as platinum and titanium by vacuum welding, one can trace the initial contact surface and the subsequently formed solid-phase diffusion zone from the buildup of intermetallic compounds. For the purpose of optimization of this welding technology, a study of platinum-titanium joints was made by that method. In the experimental 50  $\mu\text{m}$ -thick foil of 99.9% pure platinum was welded to 8-mm-thick strip of VT1-0 titanium. The process parameters were: temperature 1138 $^{\circ}\text{K}$ , pressure 6.37 MPa, welding time 900, 1800, 2700 s. Both Ti and Pt concentration profiles across the transitional diffusion zone were determined on the basis of x-ray microspectral analysis. An x-ray phase analysis with a DRON-1.5 diffractometer established the formation of three intermetallic compounds:  $\text{Ti}_3\text{Pt}$ ,  $\text{TiPt}$ ,  $\text{TiPt}_3$ . It has also been established that the intermetallic compound  $\text{Ti}_3\text{Pt}$  forms immediately and spreads into a 2.7  $\mu\text{m}$ -thick layer without shifting relative to the physical boundary between the two metals, which makes it most suitable for tracing the kinetics of the diffusion zone. The latter, under the given welding conditions, was found to spread first into platinum and then also into titanium, reaching a total width of 35  $\mu\text{m}$  (19  $\mu\text{m}$  in titanium) within 2700 s. Figures 2; references 6: all Russian.

[197a-2415]

MISCELLANEOUS

PRODUCTION OF SPECIAL ALLOY FOR COMPUTERS' RESISTOR COMPONENTS

VECHERNIY LENINGRAD, No 139 (17629), 19 Jun 85, p 1, col 8

[Text] A new product of the Leningrad Steel Rolling Plant will increase the capabilities of computers. It is very thin strip made of a special alloy for manufacturing resistors, which comprise a third of the components of computers.

The principal advantages of the new product are derived from the alloy's recipe. In the range of temperatures from minus 60 to plus 200 degrees, its electrical resistance is changed by only one-thousandth of one percent, which ensures high reliability for electronics.

The metal workers had to use advanced technologies in mastering the production of the alloy, which was developed at the association "All-Union Scientific Research Institute of Metrology imeni Mendeleyev".

FTD/SNAP  
CSO: 1842/195



UDC 621.791.927.5.042:620.178.3.002.234:621.824

FATIGUE RESISTANCE OF ROLLS SURFACED WITH ELECTRODE STRIP

Kiev AVTOMATICHESKAYA SVARKA in Russian No 2, Feb 85  
(manuscript received 18 Jul 83; in final form 26 Apr 84) pp 46-50

KRAVTSOV, T. G., Candidate of Technical Sciences, Zhdanov Branch, Odessa  
Institute of Marine Engineering

[Abstract] When the problem of surfacing small-diameter rolls with a strip 0.1-0.25 mm thick was solved, it became possible to estimate the influence of surfacing with a strip electrode on the cyclical durability of rolls. Fatigue testing was performed on model rolls 70 mm in diameter of type 35 steel, surfaced by an electrode strip with a cross-section of 20 x 0.25 mm made of type 20Kh13N4G9 steel. Two series of specimens were studied with a single austenite and two dissimilar surfaced layers, the first of which (sublayer) was surfaced by a strip of high silicon ferrite steel (3.01% Si), the second by a strip of austenitic type 20Kh13N4G9 steel. Fatigue testing was performed in air on machines which performed alternate cycle bending while rotating the specimen at 1500 cycles per minute. The test base was ten million cycles. The main reason for unsatisfactory cyclical durability of specimens surfaced with 20Kh13N4G9 steel is the presence of microdiscontinuities and microscopic fissures at the grain boundaries, which greatly decrease the strength of bonds between grains. In multiple-pass surfacing, the martensite interlayer has no influence on the process of fatigue failure. Preliminary surfacing of the sublayer of low-carbon high-silicon steel increases the endurance limit of the rolls by 18.2%. Figures 7; references 12: 11 Russian, 1 Western.  
[135-6508]

UDC 629.735.015

EFFECT OF MERCURY ON BEARING CAPABILITY OF AIRCRAFT DESIGN COMPONENTS

Kiev FIZIKO-KHIMICHESKAYA MEKHANIKA MATERIALOV in Russian Vol 21, No 1,  
Jan-Feb 85 (manuscript received 6 Jan 84) pp 91-93

RADCHENKO, A. I. and KOSORUKOVA, N. V., Kiev Institute of Civil Aviation  
Engineers

[Abstract] Mercury contamination in aircraft is related to environmental as well as safety issues. Droplets, adsorbed and trace amounts of mercury on

aircraft parts are discussed. Computer models were prepared for unprotected and coated aircraft parts subjected to mercury contamination. Calculations showed that mercury would reduce longevity and increase failure in direct relationship to a length of exposure of 45 days or more. Protective coatings, including lacquers and anode coatings, as well as mercury removal procedures, were effective in preventing such damage. If contaminated with mercury, rivets and other connecting components should be replaced. Figures 1; references 4: all Russian.  
[155-12131]

UDC 669.295

INFLUENCE OF TEMPERATURE-FORCE CONDITIONS ON WORKING CAPACITY OF ALLOYS WITH SHAPE MEMORY

Leningrad VESTNIK LENINGRADSKOGO UNIVERSITETA: MATEMATIKA, MEKHANIKA, ASTRONOMIYA in Russian No 1, Jan-Mar 85 (manuscript received 1 Mar 83)  
pp 54-59

ANDRONOV, I. N., BELYAYEV, S. P., KUZ'MIN, S. L., LIKHACHEV, V. A., TOSHPULATOV, Ch. Kh. and BUDNIK, A. I.

[Abstract] A study is presented of the influence of temperature and force conditions of testing on the working capacity of cast CuMn alloys with 50 to 89% Mn by weight, as well as alloys with the composition 50 AT.% Ti-Ni-3.2 AT.% Cu. Experiments were performed in torsion using solid cylindrical specimens 4 mm in diameter and 25 mm in gauge length. Two methods were used. In the first both heating and cooling were performed under constant load; in the second the metal was cooled under low load, heated under high load. The main purpose was to seek out optimal conditions for thermal cycling yielding the production of the greatest work. The greatest changes in amount of work were observed during the first ten thermal cycles, after which the behavior of the metal was almost independent of the number of thermal cycles. The results indicate the great promise of the use of TiNiCu and CuMn alloys in cyclical thermal engines. Figures 5; references 10: 8 Russian, 2 Western.  
[137-6508]

REVIEW OF 'THERMAL DEFORMATION OF NON-METALLIC DESTRUCTION MATERIALS', MONOGRAPH BY G. N. TRET'YACHENKO AND L. I. GRACHEVAYA., KIEV, NAUKOVA DUMKA, 1983, 248 pp

Kiev PROBLEMY PROCHNOSTI in Russian No 11, Nov 84 pp 122-123

FRANTSEVICH, I. N., academician, UkSSR Academy of Sciences

[Abstract] Current technology uses special non-metallic materials for protecting components from aerodynamic heating and other heat sources. The monograph under review covers interactions of surfaces of such materials with moving gas media and other factors involved in aerodynamic heating and

chemical effects. Glass, carbon and carbon-metal materials and deformation pattern information is offered to fill the gaps in such data. The authors present an original approach to linear expansion in layers of laminates, which makes it possible to regulate such heat effects. Heat deformation errors are shown to be a frequent cause of design problems in heat protection equipment, where with high temperature physiochemical and mechanical processes take place. This brings changes in mechanical characteristics that follow expansion and shrinkage. Present data do not permit accurate theoretical prediction of working properties of the materials tested, and the authors stress that it should be regarded as initial research only. The book should be useful to both scientific researchers and engineers in the field.  
[69-12131]

UDC 621.45:539.41

DESIGN OF FLANGE JOINTS OF AVIATION GAS TURBINE ENGINE STATOR

Kiev PROBLEMY PROCHNOSTI in Russian No 7, Jul 84  
(manuscript received 12 May 83) pp 95-101

ZHUKOV, V. B., Zaporozh'ye

[Abstract] A study is made of the flange joints of the shell and body of a stator. The stress-strain state is determined from the condition of the tight or partially open joint. Fracture of stator shells and bodies occurs through the flanges or at the points where flanges are joined to shells. The calculation model of a flange joint is refined by considering it as a series connection of shells previously designed. The theory of very short orthotropic cylindrical shells is used to define a model of the flange joints. This model can be extended to the design of flange joints of gas turbine rotors by supplementing previous solutions for rings, plates and shells to consider the forces of inertia resulting from rotation of the rotors. Figures 7; references 5: all Russian.  
[146-6508]

UDC 621.739.1:537.525;533.9.02

DISCHARGE IN ANODE MATERIAL VAPOR

Moscow FIZIKA I KHIMIYA OBRABOTKI MATERIALOV in Russian No 6, Nov-Dec 84  
(manuscript received 8 Sep 83) pp 38-41

SAYENKO, V. A. and KOLEMIYETS, N. F., Kiev

[Abstract] A study is made of the physical properties of a nonindependent arc discharge in vapor of the anode material. Experiments were performed on a discharge installation in which the discharge was created between a circular straight-channel tungsten cathode and a copper-cooled crucible anode containing the material being studied. The plasma flow was accepted by a metal collector with variable potential. Substrates of various materials were attached to the collector to study the properties of films produced from the plasma

vapor. A molybdenum diaphragm at the cathode potential was used in some experiments to study the influence of an axially symmetrically magnetic field on the discharge. Experiments were performed in a vacuum chamber with a residual pressure of  $10^{-4}$  Pa. As external cathode heating was disconnected, the discharge was converted to an independent discharge in connection with the initial stage of formation of a cathode spot, which can be used for effective discharge parameter control. The magnetic field facilitated transition to an independent discharge. The variation of ion flux as a function of magnetic field induction was nonmonotonic and independent of cathode heating current, indicating the common nature of emission of electrons in both discharge modes. Figures 3; references 8: 7 Russian, 1 Eastern European.  
[51-6508]

UDC 669:539.43:620.194.8

#### SELECTION OF MATERIAL FOR MANUFACTURE OF PROPELLER SHAFT OF SHIP

Kiev FIZIKO-KHIMICHESKAYA MEKHANIKA MATERIALOV in Russian Vol 20, No 6, Nov-Dec 84 (manuscript received 29 Nov 83) pp 84-87

SIRAK, Ya. M., FILIMONOV, G. N. and TSVETAYEVA, T. G., Institute of Physico-Mechanics imeni G. V. Karpenko, Ukrainian Academy of Sciences, L'vov

[Abstract] Specimens were manufactured strictly according to the methods used to manufacture propeller shafts for ships, some of the specimens were equipped with hot seated bushings, and all specimens were fatigue tested for long periods of time:  $10^7$ - $10^9$  cycles (the larger number for specimens hardened by cold surface plastic deformation) at 50 loading cycles per second. Testing showed the hardened layer on hardened specimens to be over 0.5 mm thick. It was found that cold surface plastic deformation significantly increases the cyclical durability not only of specimens without bushings, but also of specimens carrying heated bushings. It was found that with a test base of  $5 \cdot 10^7$  cycles, the cyclical durability of large shaft specimens both in air and in corrosive media was independent of mechanical properties for endurance limit as determined in air on specimens without bushings. The advantages of alloy steel over carbon steel in air are significant, though in a corrosive media these advantages do not appear. Figures 3; references 5: all Russian.  
[86-6508]

## ULTRAPURE METALS AND MICROELECTRONICS

Moscow ZNANIYE - SILA in Russian No 5, May 85 pp 10-12

[Article by Ch. V. Kopetskiy, Corresponding Member of the USSR Academy of Sciences and Director of the Institute for Problems in the Technology of Microelectronics and Highly Pure Materials, "In the Forefront--Metallotronics"]

[Text] To increase the technical level of computer equipment, instruments and means for automation in instrument building on the basis of the newest achievements in microelectronics, optical electronics and laser technology

--Fundamental Trends in the  
Economic and Social Develop-  
ment of the USSR for the  
years 1981-1985 and for the  
Period to 1990

The world of microelectronics is large and diverse. Its possibilities are being more widely discovered, and it more often seems to be inexhaustible. We will now tell you about how microelectronics is developing and about its manufacture technology. As a most general statement, it is possible to say that microelectronics is made up of ultra-pure crystals and ultra-pure metals. In the article "Technology for Microelectronics" (ZNANIYE - SILA, No 4), the first component was the topic. Now, about the second component, ultra-pure metals.

Ch. V. Kopetskiy, Corresponding member of the USSR Academy of Sciences and Director of the Institute for Problems in the Technology of Microelectronics and Highly Pure Metals, talks with us.

### The Second Discovery of Metals

There is a great distance between the properties of a common and an ultra-pure metal. As an example, titanium changes paradoxically in proportion to purification. Tests of the first samples obtained in 1910, not very pure samples, demonstrated that it is brittle, delicate, and lent itself poorly to working. Consequently, it was demonstrated that impurities were to blame. Pure titanium is a possessor of high plasticity and strength.

For a long time, tungsten, chromium, molybdenum, tantalum, bismuth and zirconium were considered brittle. And, in their pure state, they were as if reborn with a whole series of valuable properties. Highly pure tungsten and molybdenum, for example, may be forged, pressed and rolled, and may be drawn into wire. Moreover, they are nonsusceptible to corrosion. The greater the purity, the greater the probability of discovering the true properties of the metal, which are usually masked by impurities. In being refined, the metals discard their masks, as it were, and bare their real properties, which were up to that time unknown to man.

The "second discovery" of these metals was actually a triumph of modern solid-state physics.

We are assured that the impetus toward the broad scientific research into the properties of metal crystals of high purity and perfection, and then their intensive production was a single incident.

During the second World War, the problem of why certain electronic devices and capacitors in radio sets and cables laid along the bottom of seas and oceans went out of order without apparent cause troubled engineer-radio operators for a long time. Scientists were hooked up to look for a cause of the breakdown. They turned their attention to the finest "whiskers," threadlike crystals of tin and cadmium which were sometimes growing on the steel parts of equipment covered with these metals. Having carefully studied the "whiskers," the scientists were struck by their extremely high strength, which exceeded the strength of cadmium and tin obtained under ordinary circumstances by a factor of several dozen times, and in their magnitude approached the theoretically predicted strength of metals in general.

Further investigations demonstrated that the thread-like crystals, the "whiskers," were ultra-pure monocrystals of cadmium or tin with an almost ideally smooth surface. It is precisely this which defines their amazing properties. Illumination of the "whiskers" with X-rays detected their nearly ideal regular crystalline lattice. Thus, the high strength of the "whiskers" came as a result of their structure and purity, of the smoothness of the surface.

...On black velvet, the monocrystals of ultra-pure metals are fantastically beautiful. In the sun's rays, they glisten in shades of the color gamut which are unearthly in their purity and saturation. A monocrystal of copper is dark golden, that of silver is a dark mirror blue and a bismuth crystal is a pearly matte color.

All of them, as is the case with monocrystals of ultra-pure indium, antimony, cobalt, lead, nickel, yttrium and samarium, hold world records for purity. They assay out to an extremely high 99.99999 to 99.999999 percent. The degree of purity for samples of niobium, molybdenum, tungsten, zinc, cadmium, and tin also approaches record values.

These large monocrystals of the metals, ten and more centimeters in length, were grown in the laboratories of the newly established Institute for Problems in the Technology of Microelectronics and Highly Pure Materials.

## A Metallic, Almost Invisible Architecture

Everyone has something to do with semiconductor devices to one extent or another when they listen to a transistor radio, watch a color television set, make calculations with a microcomputer or work at a lathe with numerical program control.

Highly organized integral microelectronic circuits are the center of many of these pieces of equipment, devices and machines. The working principles and components of such circuits are universal. They can not only process information logically, they can also remember it, which is no less important. To do this, semiconductor memory elements are utilized. They are usually manufactured in the form of integrated circuits on a layered base: metal-oxide-semiconductor and metal-nitride-oxide-semiconductor. And, of course, the metals are ultra-pure.

Inside the minuscule, semiconductor crystal, with a total volume of several cubic millimeters, there is hidden a complex architecture made of metal. These are the contacts and electrical "bridges," very thin films of ultra-pure aluminum or gold, capacitors and other components of a super-miniature device. The number of components is counted in the tens of thousands, and they are situated on an area and in a volume of several millimeters.

The development of large integrated circuits (LIC) promises to make the use of computers universal for automatic control of production processes in manufacturing, included robot-assisted. This is not only real, but economically expedient. Why?

The use of LIC permits the size of computers to be reduced significantly. Single-crystal microprocessors, the basic unit of the machine, which performs the arithmetic and logical operations, have been developed. These microprocessors are LIC with programmable (rearrangeable) logic. And the program for microprocessor operation is stored here, in a memory device built into a LIC.

From day to day the appearance of a monocrystal microprocessor equal in capabilities to a large computer is anticipated.

As distinct from the typical computer, microprocessors and microcomputers are easily built into a lathe, television set, automobile, motorcycle, into equipment of all possible types, commercial, domestic or medical. Microprocessor technology is becoming that means which will help optimize work in all sectors of the national economy, its economics. For example, machine tools automated using microprocessor technology--machining centers serviced by robots--increase labor productivity several times over. It is possible to achieve even more upon development of flexible automated factories based on them, a new trend in the development of machine tool building and other sectors. Full-scale automation is possible only on the basis of microprocessor technology, which is equally capable of controlling and analyzing the work of both a single lathe and an entire sector of the economy.

The integrated circuit is an uncommon "microbuilding." It is built at once, simultaneously on all floors, and once built, cannot be corrected. Therefore,

one speaks of the probability of success when developing each individual integrated circuit. But this does not stop the technologists, for the probability of a desired good quality circuit is nevertheless adequately high. And the effectiveness is enormous. In the forming of a single integrated circuit, the quantity of material is less by a factor of thousands, hundreds of thousands, than were one to make the same item from ordinary components. The labor productivity increases fantastically, by a factor of one million. Such are the fruits of the science and technology of microminiaturization.

And the development of a component base for microelectronics, magnetoelectronics, optical electronics and superconductor cryoelectronics permits us to hope for the development of a new generation of particularly miniature high-speed computers in the very near future.

### Why Do Electrons Stumble?

The atoms of metal crystals are densely packed. At their lattice points there are positively charged ions, "swimming" in the electron gas, made of electrons lost by them and "collectivized." The role of electron gas in metals is great. It, as it were, files, the lattice constructed from mutually repelling ions. Let us imagine that somehow we removed the free electrons, "forced" them from the metal--the ions, having identical charges, will repel each other and fly apart in all directions, and the lattice will "explode."

The properties of the electron gas determine the color and sheen of the metals, their thermal conductivity and their electric conductivity. Apply a constant voltage to the metal and the electrons will start their movement. Their average velocity does not increase with time. Evidently, they experience something like friction when in motion, "stumbling" upon obstacles which arise in their path. Their velocity increases and suddenly...falls. Thus the movement of electrons is spasmodic and their average velocity characterizes an electric current.

An electron "stumbles" upon various objects. First and foremost, they collide with "foreign" atoms from impurities. This is the main thing, this is why the absolute purity of the metal is so important.

In our discussion we have frequently used the term "superpure metals." In microelectronics, this requirement for almost ideal purity is mandatory. Without such a feature for all of the metals used here, from aluminum to gold, microelectronics and its modifications are simply impossible.

In a super-pure metal, the electrons of conductivity move amazingly freely, without colliding with the millions and billions of impure particles and flaws in the metal structure which are present in the same abundance. Moreover, a super-pure metal behaves almost like a superconductor. The unique "superconductivity" is accompanied not only by a sharp reduction in power losses; it also automatically solves the problem of heating up in all semiconductor devices.

While in operation, semiconductor devices may literally heat up to incandescence, and heat elimination from them changes into a problem which is almost



or totally insolvable from a technical point of view. Given super-pure metals, this problem either does not arise, or, should it come up, it is in significantly "softer" terms.

Further, the stream of information (in any form--wave, charge, etc.) constantly in circulation in the electronic circuit also collides with the multiplicity of obstacles in ordinary metal. It is apparent that in a super-pure metal the flow of information can travel unhindered.

To a pure crystal, each speck of dust which touches it is fatal; it will gradually and inexorably ruin it. Therefore, production of pure substances is totally isolated from the external environment.

Computer controlled fans, vacuum cleaners and air conditioning units insure the requisite cleanliness and sterility of the air in the work facilities... The fact that the building is usually constructed like a layered pie--one floor is production, the next, engineering provisions for sterility--indicates the importance of this equipment. Branching out, like an octopus, the vacuum system enmeshes the entire building with its tubes.

It is no less complicated to keep a substance in its pure state than it is to purify it. One way of maintaining an achieved level of purity is to keep the metal at low temperature--in liquid nitrogen or even in liquid helium.

#### New Faces of Microelectronics

Magnetostatic waves, waves of magnetization arise in thin crystalline ferromagnetic films. Now electron devices based on the stimulation and propagation of magnetostatic waves are being studied and developed. These are the devices of magnetoelectronics.

The search for ways of further electronics miniaturization led to the study of the effects of super-low temperatures on their characteristics. They subsequently recalled the so-called Josephson effect, predicted in 1962 by the English student Josephson, now a Nobel laureate. The device, the "Josephson junction," was constructed from two super-conducting electrodes separated by the thinnest (10-50 Å) layer of a dielectric. Under ordinary conditions, even at super-low temperatures, an electric current does not flow through the isolator. However, due to the superconducting state of the electrodes, an electric current is possible through the isolator, and it depends on the electric and magnetic fields which are applied to the junction. One or several such junctions can function as a detector, amplifier, element of logic or memory register.

Due to super-conductivity, at a temperature of only  $4.2^{\circ}$  K such a device, when in operation, puts out 1/10,000 of the heat put out by an ordinary transistor. This was a discovery for the developers of the computers of the future. They no longer relied on semiconductors, which require too much energy. A computer the size of a football field and which is based on semiconductor integrated circuits should give off a kilowatt of energy per second. Such a computer would be unable to function--there is no means for extracting such a large quantity of heat. At the same time, a computer built using super-conducting electronics would give off 0.1 w in all, ten thousand times less!

Josephson junctions with electrodes made of niobium and other high melting metals are most stable in operation.

The development of lithography methods, vacuum equipment and the use of high melting metals permit us to hope that production of computer components based on Josephson junctions will begin in the near future.

Research performed by scientists from the Institute of Solid State Physics in many ways discovered the behavior of impurities in a metal, their effect on its characteristics. Sites where "foreign" atoms attracted by the boundaries of metal grains congregate were detected. Thus, in construction grade steel, at the grain boundaries and close to them, phosphorous and sulfur impurities congregate in quantities 50 times greater than throughout the volume on average. Two or three atomic layers here are mostly composed of sulfur and phosphorous. This is precisely why at low temperatures, under conditions of winters in Siberia and the Far North, this steel becomes brittle like glass.

To produce metals of record purity, electron beam zone smelting in a high vacuum is most often used: during crystallization of the solid from the melt, the impurities remain in the melt residue. By the way, even in antiquity, fresh water was produced from salt water in winter time.

In the apparatus for electron beam zone smelting, an electron bundle is directed at a narrow section of a metal rod. Passing the electron beam over it, they slowly displace the melted zone, leading it to the end of the rod: the impurities also accumulate in the zone which remains molten. Multiple repetition of this process permits the metal's purity to be increased more and more.

Products from the Novosibirsk Tin Combine are highly regarded in the world market. In a workshop white from floor to ceiling, refiners wrap ingots containing 99.9999 percent tin in their assigned packaging.

Soft and pliable, at first glance the metal did not want to let go of its numerous accessory minerals for a long time (nearly the entire Periodic Table of Mendeleev accompanies tin). The problem of problems was to get rid of them. But in high-vacuum electric refining equipment, in airless space, hidden within the steel jacket of a furnace and creating a sterile environment, at a temperature higher than  $1000^{\circ}$  the impurities boil. The vapors are directed off into a condensation zone, from whence the impurities are poured off into a waste receptacle. And the tin, as a result of this distillation process, takes on a purity "not of this earth." And by the way, six '9's is not the limit. At the combine, they feel that all the possibilities exist to purify tin from contaminants down to millionths of a percent. Mass production has yet to know such high purity of a metal product.

In recent years, pure metals are being obtained from metallorganic compounds. The technology of this method is refined and simple. The metal is evenly heated in a carbon monoxide stream. Carbonyl compounds of the metal atom with several molecules of the carbon monoxide, the carbon monoxide fumes, are formed. These compounds are gaseous and are easily removed from the impurities and ballast contained in the initial metal (or ore). The gas-compounds are passed above the surface, heated to  $100^{\circ}$ - $200^{\circ}$  C. When they touch it, they decompose into the metal and a gas. The metal atoms are precipitated on the surface and the gas escapes.

What requirements are imposed on materials of high purity expressible in percentages of a mind-spinning decimal fraction, with six, seven and more '9's after the decimal?

They say, "A speck of dust is small, but it eats away the eye." When producing a material with a high degree of purity in the atmosphere of a workshop, a content of just several dust specks no more than a micron in size per cubic meter is allowable.

The equipment of super-conducting electronics possesses high sensitivity. Extra-sensitive magnetic current and field gages have been made on their basis which are capable of fixing the magnetic fields of not only the heart (magnetocardiography) but of the brain as well (magnetoencephalography). Cardiologists and neurosurgeons have received a new precision tool for their research and practice.

#### Metal--It's Almost a Vacuum

Research on samples of metals of super-high purity promoted progress in the study of the properties of conductivity electrons. In order to "catch" the increase in the length of the free path of electrons, experiments were conducted on monocrystals with a high degree of refinement of electrically active impurities and at the cold of outer space--the temperature at which helium boils--and even lower. Electrons traverse their record free path of from 8-10 millimeters in super-pure samples of indium grown by colleagues of institutes of the USSR Academy of Sciences. In other words, the pure metal behaved to a known degree like a vacuum!

A new method for analyzing the purity of metal has been developed by candidate of physical and mathematical sciences V. T. Petrashov (Institute of Solid State Physics of the USSR Academy of Sciences). The method is particularly advantageous in those instances when the impurity content is less than  $10^{-4}$  percent. It is based on the property of a particular type of electromagnetic waves (helicons) to attenuate in a number of metals in proportion to the concentration of impurities in them. The method is suited for analysis of the purity of all metals in which the propagation of helicons has been observed--lithium, sodium, aluminum, potassium, gold, lead and others. Its sensitivity increases with an increase in the purity of the metal. The absence of making contact with the substance being analyzed permits measurements to be taken when the specimen is inside a sealed ampule.

A piece of equipment to determine the free path of conductivity electrons (a certain similarity to super-conductivity) in record pure metals at the temperature of liquid helium has also been developed on the basis of the phenomenon of helicon wave attenuation.

The helicon waves themselves are the attenuation of electromagnetic waves emitted by a plasma of charged particles. This is again an attempt to see pure metals as something akin to a vacuum. It is only in a vacuum that similar plasma appears.

The study of pure metals can lead to the appearance of a new trend in science and technology, metal electronics or metallotronics. We are talking about

creating guided electron beams in a metal and controlling them in a manner similar to the way it is done in an electronic vacuum tube. For in a known sense, a metal specimen with a high degree of purity is similar to a vacuum for conductivity electrons. In it, their density is  $10^{22}$  electrons per cubic centimeter, which is greater than the density of charge carriers in semiconductors by a factor of several hundred thousand times. It is clear that metallotronics should sharply increase the efficiency, the high-speed response of computer and control systems.

Now this idea no longer seems like fantasy. Experiments with such pure metals as indium and bismuth, with a free electron path greater than 5 millimeters, which have been performed at the Institute of Solid State Physics by Dr. of Physical and Mathematical Sciences V. S. Tsoy, have demonstrated the possibility of focusing conductivity electrons inside a metal specimen and controlling their trajectories using a magnetic field.

Microbridges manufactured by local thinning, down to a single micron, of massive ultra-pure metal crystals may become the fundamental components for the newest branch of microelectronics--metallic electronics. A microbridge is, in essence, a narrow "bridge" 100 microns in length, which joins two metallic monocrystals.

At temperatures close to absolute zero, it is possible to pass over such a bridge an electric current in the tens of amperes of immense density-- $10^9$ -- $10^{10}$  amperes per square centimeter. The bridge will not even heat up, although the most high-melt metal vaporizes at a current density of  $10^5$  amperes per square centimeters. This is possible only because of the exceptional purity of the metal from which the bridge is made.

In motion, the rapid flight of electrons through the "vacuum" of the metal monocrystal of the bridge, a violation of Ohm's Law has been observed. More precisely, it loses the form of simple proportionality. The dependency between current and voltage turns out to be more complex, non-linear. This is observed firsthand in all vacuum devices. Such a non-linear dependency of current on voltage is the basis for the operation of all tube and semiconductor devices.

When the first computer was constructed using electronic tubes, it turned out that its weight was very substantial--30 tons! By itself it occupied a hall of 150 square meters. The modern microcomputer, which surpasses the first both by its high-speed action and its memory volume, reminds one of a thick book. Its dimensions are no greater.

Metallotronics is just in the process of study and formation. The time of precision characteristics is still ahead. But it is possible to predict with assurance that metallotronics is a new, revolutionary jump in electronic technology.

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