MULTICOMPONENT Ti-Si-BASED SYSTEMS

or

PHASE RELATIONSHIPS AND PROPERTIES OF MULTICOMPONENT Ti-Si-BASED ALLOYS
AS FUNDAMENTAL BACKGROUND FOR ELABORATION OF HIGH-TEMPERATURE TITANIUM MATERIALS

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Scheme of the presentation

- Homogeneity ranges of the phases
- Eutectics:
  - extension of the binary eutectic into the multicomponent system
  - search for new binary and ternary eutectics
- Phase relationships in the solid state
- Links phase diagram - property
Ti-corners of Ti-Si-p-element melting diagrams

Two tendencies
1. Crystal structure of 5/3 binary intermetallics
2. Difference in atomic radii of the p-elements

N. Antonova et al., 1998

Our prognosis

M. Bulanova et al., 2002, to be published
Melting diagrams of Ti- corners of Ti-Si-Al-p-element systems

![Diagrams showing phase relationships in Ti-Si-Al systems for different Si concentrations: (5Si + 5Ge), (5Si + 5Sn), (9Si + 1Sn), and (7Si + 3Sn), with phase regions labeled α, β, and Z.](image-url)
Isopleths of Ti-corners of Ti-Si-Al-p-element systems
Maximum solubility of $\rho$-elements in $d$-metals

![Graph showing solubility of $\rho$-elements in $d$-metals]
Formability of the 5/3 ternary compounds with the $W_5Si_3$ structure type

$$F = \left[ \frac{\Delta r_X}{r_{X_{\text{max}}}} \right] \times \left[ \frac{(r_M - r_{X_{\text{max}}})}{r_M} \right]$$

$\Delta r_X$ – difference of the atomic radii of $p$-elements,
$r_{X_{\text{max}}}$ – atomic radius of the larger $p$-element atom,
$r_M$ – atomic radius of $d$-metal.

0.023 < $F$ < 0.032.
Microhardness of Ti-matrix

M. Bulanova et. al, 1998, 2000

H_v
kg/mm^2

Al, % (am.)

Sn/Si

90Ti
10(Si+Ge,Sn)

60Ti
10(Si+Ge,Sn)

Sn, at.%

M. Bulanova et al., 2003

H_v, kg/mm^2

Sn, at.%

primary β transformet into α

primary β with α precipitates

β+Z

primary α

β+Z+α

250
300
350
400
450
500
0 5 10 15 20 25

β+Z

primary β transformet into α
Lattice spacings and microhardness of the primary Z
Correlation of microhardness of eutectic mixtures with the solidus temperatures

M. Bulanova et. al, 1998, 2000
Long-term hot hardness of Ti-Si-Sn-Al alloys

Data obtained by Dr. O.Ban’kovsky
Isothermal sections of the Ti-Zr-Si system

N.H. Salpadoru et. al, 1995
Ti-corner of the Ti-Zr-Si melting diagram

our data
Isopleths and some properties of Ti-Zr-Si alloys

M. Bulanova et. al, to be published

Two factors in competition

- dispersity of the structure
- the temperature

[Graphs and images showing phase diagrams and hardness data vs temperature]
Isopleths and microhardness of the Ti-Zr-Si-Al alloys

Graphs showing phase diagrams and hardness measurements.
Ti-R phase diagrams
from [T.Massalski2]
Ti-Dy phase diagram

M. Bulanova et al, 2003, to be published
Long-term hot hardnes of Ti-Dy-Si-Sn-Al alloys

![Graph showing the long-term hot hardness of Ti-Dy-Si-Sn-Al alloys](image-url)
General conclusions

• For the practical usage phase fields with participation of the $\text{Ti}_3\text{Si}$-phase can be ignored

• Understanding of the relations of the details of phase diagrams, crystal structure of the phases and metal chemistry of the components on the one hand and mechanical properties of the phases and materials in the whole on the other hand is absolutely necessary for effective process of materials elaboration