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This joint ASM-IMS meeting on applied metallurgy was attended by a good representation of academia and industrial scientists and engineers. A wide range of topics was covered; from non-destructive evaluation, joining, failure analysis, to electronic materials. The diversity and sophistication of interests shown by the Israeli indicated that theirs is a growing and forward-thinking industry, and that joint international conferences like this one are in fact mutually beneficial.

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I don't recall ever attending a scientific conference where the president of a country officiated at the opening ceremonies. But this is exactly what happened in this land of surprises, Israel, during the International Conference on Applied Metallurgy, 4-8 April, in Tel Aviv. Prof. E. Katzir, the President of the State of Israel, gave a talk entitled "Science and Technology" before the opening session of this Conference, which was sponsored jointly by the American Society for Metals (ASM) and the Israeli Metallurgical Society (IMS). Katzir addressed his remarks to the participants, speaking not a politician but as a scientist (he is a renowned biophysicist), and strongly urged the attendees to assume a strong moral posture. He said that he was "...most obliged that the ASM wished to lend a hand to another free society." It was a highly philosophical and extremely touching speech.

This unique cooperative ASM-ISM enterprise attracted some 60 American metallurgists and several hundred Israelis. The time of year could not have been better chosen--the land of Israel was in radiant bloom, and for a first-time visitor the expansive green fields were remarkable to observe. But Israel had more to offer the participants than scenery and history. As one of the Israeli conveners observed, this small country's launching of a joint meeting with the ASM might be viewed as rather pretentious. However, as the Conference progressed it became clear that the metallurgy of Israel is small in size only--certainly not in quality.

The American chairman, Abraham Hurlich (Convair), departed from his opening remarks in English, to speak Hebrew. B. Cina (chief metallurgist of Israeli Aircraft Industries and the President of IMS) presented a welcome speech with a distinct Scottish accent (he received his PhD at the University of Glasgow). M. Amit, General Manager of Koor Industries of Israel, argued that Israel is "lagging behind." This admission, however, will, according to Amit, translate into Israel's new battle cry: EXPORT! Speaker after speaker admonished the metallurgists of Israel to transform their energy and ingenuity into commercial success. H. Bar Lev, Minister of Commerce and Industry, reviewed the metals industry and said, though still young, it is fast developing. In fact, in 1975 Israel exported $300 million in metals products. This, he said, will be further enhanced due to recent trade agreements with the EEC and the US. These discussions of economics, pricing policies, the need to export, etc., were an appropriate starting point for this four-day Conference on the industrial aspects of metallurgy.

The symposium was comprised of invited and contributed papers, as well as workshops on a wide range of topics. Since there were a number of simultaneous sessions (and since this report is a product of one-man coverage), I can only here give the high points. I hope, however, that these notes will convey the level and the style of this meeting, as well as something of the content.

The first day concentrated on nondestructive testing (NDT) subject of immense importance to Israel. The major paper was given by Prof. R.C. McMaster (Ohio State University), whose presentation was of a show-and-tell nature, but nonetheless very interesting. He likened NDT to Israel's trying to survive against unknown odds and circumstances. McMaster feels that the best NDT is an extention of our senses, enabling us to make an intelligent evaluation of our universe. He stressed that practitioners of NDT have an awesome responsibility, and felt that NDT has probably saved far more lives than has medicine.

McMaster reviewed the wide applications of modern NDT techniques, including acoustic emission and holographic methods. He described the possibilities and limitations of liquid penetrant and magnetic field tests, and reviewed ultrasonic methods, especially in large tanks for reactor vessels. The Israel Institute of Metals has developed a small, automated eddy current device, and McMaster praised such efforts. He described some of his own contributions to xeroradiography, where a dry x-ray imaging system--utilizing photoconductor radiation detection--can be reused, time and time again. McMaster explained that such equipment, which can give inexpensive industrial inspection, is best for light alloys, organics and thin layers of dense materials, for exposure below 200 kV. He discussed scanning-detector systems having a high sensitivity to x-rays and gamma-rays, and mentioned that more development work is needed for image-enhancement and in applying digital techniques. Neutron radiography, McMaster feels, is a comer, as will be other types of high energy radiation. Thermal and infrared tests are in everyday use, with some real impetus being delivered by military-based infrared imaging technology.

McMaster discussed computer analysis and control, and stated his strong bias in favor of automated NDT. On-line computer-controlled processes, together with an NDT-feedback loops, will be the production systems of the future, in welding and other fabrication techniques.

The subsequent talks on NDT involved both the metallurgical aspects and pure instrumentation. Thus, J. Pessach (Ben Gurion University) discussed the determination of grain size in uranium by ultrasonic attenuation. Metallography is both destructive and inadequate to give a detailed picture of reactor rods. His group has developed an ultrasonic attenuation method which is able to determine grain size in the range of 50-200 microns.

The parabolic relationship between grain size and ultrasonic attenuation coefficient is used in this technique.

A.A. Friesern (Weizmann Institute) discussed the applications of holographic techiques to NDT. He is interested mainly in real-time holography; and though it is extremely difficult to interpret the interference fringes from the point of view of an absolute value of strain, it is nonetheless possible for holography to detect cracks and other pathological symptoms in materials. Thus, he showed the NDT analysis of a honeycomb structure, where the detection of debonding is made readily apparent with real-time holography. Friesern also showed holographic photos of vibrating structures, enabling engineering-mechanics analyses of dynamic systems. He also showed how a tunable dye-laser can be used to generate a composite holograph, thus permitting the mapping of surface profiles. It was obvious from this talk that there are numerous potential applications for holographic methods in NDT. It appears certain that the instrument people have barely scratched the surface of this technique.

R.L. Lawrence, R.H. Buchanan (Univ. of Alabama) and F.C. Berry (Chicago Bridge & Iron) discussed problems related to ultrasonic evaluation of full penetration welds in pressure-retaining bi-metallic and tri-metallic joints. In this study, recognition was made of possible ambiguities that may be introduced due to the scattering and reflection of ultrasonic waves by interfaces in polycrystalline materials; e.g., the dendrite structure of the weldment. There was, in fact, correlation between metallographically observed dendrite spacings and acoustic wavelength. They discussed recommended techniques for discontinuity evaluation in as-deposited Inconel weld metal.

A. Shavit and M. Oron (Hebrew University) correlated ultrasonic NDT and the details of SEM studies in order to characterize the defects in duralumin thick-walled tubes. They will attempt to "test" the ultrasonic method (with good acoustic coupling) by the SEM method. It appears that the ultrasonics, as used here, is able to detect flaws down to 0.1 mm in size. It is interesting to note that very small voids, about 0.01 mm in diameter, which were found to be evenly distributed within the specimens by SEM, could not be detected by acoustic methods. Although these voids do not have a dangerous character, it seems clear that there are indeed circumstances where ultrasonics will miss some possibly significant defects. More work of this sort is clearly called for.

Acoustic emission from welding processes was the topic of an extremely interesting paper by J. Baruch, S. Yaron and

S. Golan (Israel Institute of Metals), who presented an interesting approach to on-line NDT of welding processes. They have developed an arrangement which uses acoustic emission to detect the sharp stress-pulses that accompany hot cracking. Of course, just as with any application of acoustic emission, the major difficulties encountered are not due to lack of sensitivity, but rather to the extraneous noise from which it is difficult to separate the significant data. In addition, for this problem, electric arc welding introduces electrical noise and problems arising from thermal stresses. Thus, it becomes particularly difficult to detect hot cracking which may occur. To solve these problems Baruch *et al*. developed a system consisting of a differential ferroelectric transducer, coupled to one end of a sheet specimen by a viscous resin. Cracking was induced in the 2-mm-thick austenitic stainless steel sheets by drilling holes along the (gas tungsten arc) weld path and jamming copper plugs into them. After the arc passes, and the copper plug solidifies, cracking occurs. It was found that the hot cracking could be detected with very high sensitivity. The "deleterious external mechanical conditions" (e.g., loose clamping, filler-rod addition, manual welding) surprisingly did not present a problem. However, metallurgical factors could be confusing (e.g., martensite formation for type 302 stainless steel). This imaginative application of acoustic emission could point the way towards new thinking in the metals fabrication industry. Looking at this work, McMaster's remarks, as well as other discussions of acoustic emission could lead even an ardent sceptic into suspecting that the technique will grow beyond the stage of a laboratory curiosity.

Further talks on NDT were more or less standard expositions of radiography and ultrasonic techniques applied to some tough problems--e.g., radioactive fuel elements, and the monitoring of stress corrosion cracking. In subsequent talks on fracture prevention and analysis, the NDT theme was to recur. It was clear that the participants were appropriately keyed by this initial NDT-overview session. One further point: there is little formal training available on NDT, and area crucial to cost-effective production methods. Educators please take note.

In the thermomechanical processing (TMT) portions of the Conference, F.U. Boulger (of Battelle's Columbus Laboratories) reminded the participants that TMT has come to mean a controlled sequence of working temperatures, deformations, heating schedules and cooling treatments designed to produce a superior combination of properties. Although any deformation process is, in fact, TMT, the term as used industrially and by Boulger refers, of course, to a programmed sequence of forming of both ferrous and non-ferrous alloys, at low or high temperature. The idea started

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Though there is no clear understanding of the details of the response of metals to TMT; the improvements obtained are usually attributed to grain size refinement, modifications in distribution and density of dislocations and precipitates. Boulger reviewed experience with aluminum and titanium alloys, super-alloys and steels. The demand for higher strength steels originally sparked developments of TMT. The deformation of metastable austenite below its recrystallization temperature (prior to the martensite transformation) was effective, but the practical problems remained difficult (i.e., the need for careful temperature control and high deforming forces). On the other hand, for the case of steel, hot-working processes are easier to control, the loads being easily handled by commercially available equipment.

N. Atzmon and A. Rosen (Technion) applied combined heat treatment and plastic deformation to a maraging (300) steel, and studied the effects of reverted austenite on the strength of the product. A. Blas and A. Ariele (Israel Aircraft Industries, Ltd.) (AIA) presented a paper on the hot forming of titanium. This is an important problem in the titanium forming industry since the inherent properties of the metal give rise to splitting, buckling and high springback. Hot forming can overcome these difficulties, and the IAI has invested a good deal of effort in this process (a separate report will be written on the subject of these efforts at IAI).

Not exactly TMT, but nonetheless innovative metal fabrication, is the electroslag refining process (ESR). In a comparison between conventional forging and ESR, H.J. Wagner (Israeli Ministry of Defense, formerly of Battelle's Columbus Laboratories) and K. Bar-Avi (Taas) reviewed ESR and described experiments with a Cr-Ni-Mo steel for gun tubes. They argued that direct forming by ESR yields a clean, inclusion-free (at least large inclusions) casting with the cast structure oriented more towards the vertical than would be the case for conventional castings. Also, due to incremental solidification, ESR leads to greater chemical homogeneiety and a microporosity-free ingot. In fact, as reported here, by using chemical analysis and firing tests, ESR as-cast ingots seem to satisfy the needs of the fabricators of forgings for high performance applications.

The above papers plus the displays of Israeli industry at the Conference led to the conclusion that Israel recognizes the importance of modern metal fabrication techniques and is rapidly applying what is available in the field to its own needs. This applies as well to the microelectronics industry, a good portion of which is materials-based.

On the subject of electronic materials, a review lecture was presented by I.A. Blech (Technion), who looked at materials aspects of semiconductor technology. He made a strong case for the thesis that today's electronic industry is largely dependent on materials engineering in one form or the other. Reviewed were preparation and processing techniques, including: growth of high-purity single crystals; epitaxial growth by gas and liquid phase techniques, with mention of the molecular beams technique; thin films prepared by oxidation, anodization, CVD, plasma deposition, filament evaporation, EB or RF evaporation, and a range of sputtering methods; sintering of powders for hybrid circuits; injection molding (for manufacture of the package). Fabrication, processing and assembly require unique approaches for electronic materials. Further, the oxidation and doping stages--not to mention cleanliness--are special jobs extremely challenging to the materials technologist. Blech reviewed the problems of stability of devices, including problems arising from interdiffusion, electromigration, corrosion, oxidation, microstructural changes, creep, and fatigue. Of course, the entire arsenal of the materials scientist is required to characterize these materials and control the very demanding processes.

These features and problems which enter into electronic manufacture promoted Blech to conclude: "The sensitivity of semiconductor devices to impurities, stresses and adverse environment makes them a fertile ground for materials and process improvements," and, I should hasten to add, marvelous opportunities for academic research and training.

Additional papers on electronic materials--more properly, materials for the electronic industry--strongly supported this view. For example, S. Shtrikman (Weizmann Institute) reviewed recent developments in magnetic alloys and their applications. He somewhat criticized the "classical metallurgist" (by which one must suppose that he means physical metallurgists) for his lack of interest in magnets, both rare-earth transition metal types and, more recently, the amorphous magnets. Another recent product of research has been the Laves phase compound, $ReFe_2$, showing giant magnetostriction, thus, having obvious application as a transducer. Amorphous alloys such as gadolinium-cobalt, are hot items for bubble memories.

I. Goldberg (Ministry of Defense) discussed hybrid microelectronics, from the point of view of materials and processes. N. Klein (Technion), in a related paper, reviewed the electrical insulating properties of materials.

This group of papers, preceded as they were by a session on NDT, and followed by papers on corrosion and failure analysis (some, unfortunately presented concurrently), point to the tremendous opportunities for materials specialists in the field of electronic materials.

Corrosion and protective metal coatings were covered in eight papers, the first of which was an excellent keynote lecture given by Prof. M.G. Fontana (Ohio State University). He was quite candid on the lack of sufficient corrosion expertise available today and stressed the need for education and training. He reviewed eight forms of corrosion: (1) general, (2) two-metal, (3) crevice, (4) pitting, (5) intergranular, (6) selective leaching, (7) erosion corrosion, and (8) stress corrosion. Fontana believes that this categorization of causes can lead the way to prevention and remedies: (1) more resistant alloys, (2) cathodic and anodic protection, (3) metal purification, (4) nonmetallics, (5) alteration of environment, (6) design, (7) organic coatings, (8) inorganic (including metallic) coatings. These remedies, when intelligently applied, can go far towards alleviating problems arising from corrosion. Fontana discussed product liability, standardization of procedures and equipment to achieve more economical operation. He gave some interesting and colorful examples of the corrosion failures that he had seen during 40 years (!) of experience in solving corrosion problems. It was an extremely interesting presentation.

In a talk on the metallurgical factors affecting corrosion, J. Zahavi (Israel Institute of Metals), pointed out that the metallurgical condition of a given alloy can have a great effect on corrosion resistance and the mode of corrosion. These variations can arise from differences in thermal and mechanical treatment and from the fabrication procedures. For example, exfoliation can be associated with strong preferred orientation in pipe. Using Auger spectroscopy, A.E. Yaniv (Ministry of Defense, Israel) and I.B. Lambsden and R.W. Staehle (Ohio State University) studied the composition of the passive film on ferritic stainless steels. The films were formed by anodic polarization in various solutions with different pH's. One of the conclusions of this study points to the role of molybdenum in improving the corrosion resistance of stainless steels in H_2SO_4 and HCl. These workers feel that this improvement could result from the assistance of molybdenum in the initial stages of formation of the passive film. M. Meron *et al.* (Israel Aircraft Industries) discussed the development of an electrochemical hydrogen detection gauge for hydrogen permeation measurements. Further papers were presented on special examples of corrosion failures, which occur in industrial environments.

Following the corrosion sessions, and partly concurrently with them, were sessions on failure analysis. Cina opened these sessions with a discussion of the problematic areas in metallurgical failure analysis. He, in fact, set a high tone which in general is difficult to meet: "For failure analysis to be fully efficacious it must result not merely in identifying the cause of a particular failure..., but should provide a detailed estimate of the service stresses and conditions leading to such a failure." In other words, Cina was asking for a thorough case history of a part, including its environmental, stress and thermal history. A big order--difficult, if not impractical, to satisfy. In operating systems, however, he believes that such a philosophy should be considered. He argued that residual stresses are a case in point. Due to ignorance as to their presence and level, they can play a significant role in failure. Chemistry and thermomechanical treatment will, of course, influence failures. Therefore, these must be understood thoroughly as well. Cina, in much the same way as McMaster did with NDT, stressed the vital importance--in terms of lives and property saved--of proper failure analysis.

Less philosophical but rather educational case-studies followed, ranging from fabrication problems in aerospace to corrosion-induced failure in the nuclear industry.

The entire Conference was dominated by a sense of mission on the part of the Israelis. It must be admitted that the Americans were a bit awe-inspired by much of the gung-ho attitude of the Israeli engineers present. There was a plant visit to the Israeli Aircraft Industry near Tel Aviv. Virtually all of the machinery equipment was less than 10 years old and almost all numerically controlled. In fact, both the Conference and the plant visit were shown cases for the IAI's capabilities, especially in materials and process engineering. IAI's advanced metals development groups, for example, have devised special equipment for hot-forming titanium alloy parts. As mentioned above, under the careful tutelage of Cina, the metallurgical investigations of engineering failures have developed into an impressive activity. In the processing area, IAI has developed a new heat treatment for the 7075 aluminum alloy which can be applied to both raw stock and to final parts, yielding improved stress-corrosion resistance. Superalloy heat treatments have also been developed which will heal high-temperature creep damage. NDT, composite development programs, novel forming methods, etc., look very much like high technology, though on a scale smaller than the Americans are used to. Nevertheless, the impression was always present that there is much more that has to be done. Certainly, as mentioned in a recent article (ESN 30-6:268) there is a thought prevailing within Israel that more directed research and education are required. And it is clear that the economy is in trouble, but it is also clear that both talent and dedication are present in unique abundance. If the view which we saw of this small country's industry is at all realistic, their prospects for improving exports are good.

The ASM played an extremely beneficial role in this activity and one that could be extended more widely to other countries, and, indeed, emulated by other professional societies.