Matthews and *H. J. Bunge* (Technische Universität Clausthal, FRG) reported work on the texture and microstructure of lath martensite and *H. Berns* (Ruhr-Universität Bochum, FRG) traced the development of new martensitic nitrogen steels, discussing his results with special reference to the technological applications of this steel. *D. Löhe, R. Bartels* and *E. Macherauch* (Universität Karlsruhe, FRG) then dealt with the interaction of dynamic strain aging and the transformation of retained austenite to martensite, after which *K. Ullako* and *J. Pietikäinen* (Helsinki University of Technology, Espoo, Finland) reported their results on the carbon redistribution in low temperature deformed and aged martensite. Fe-Ni-C alloys were the subject of a paper by *X. M. Zhang* (Institute of Metal Research, Shenyang, China) who had studied the effect of plastic deformation on the lenticular martensitic transformation. *T. Abe* and *C. M. Sellars* gave an overview on the effect of thermo-mechanical treatment on the reverse transformation behavior and micro-duplex formation in Fe-Ni alloys. The last lecture of this session was given by *H. Vetters* (Institut für Werkstofftechnik, Bremen, FRG) who discussed the influence of unidirectional and cyclic loading on the martensite formation in austempered ductile iron.

The second session on steels was concerned with the mechanical properties. It began with a paper by *E. Gautier* and coauthors (Laboratoire de Science et Genie des Materiaux Metalliques, Nancy, France) on the transformation plasticity and resulting microstructures for strain induced martensitic transformation in Fe-Ni-C alloys. *Y. Zhang* (on leave from Shangai Iron and Steel Institute, China) reported on reverse austenite and its effect on mechanical properties. The microstructure-strength relationship of low carbon bainite and martensite was discussed by *W. Österle* (BAM, Berlin, FRG), and then *A. Schulz-Beenken* and *H. P. Hougardy* (Max-Planck-Institut für Eisenforschung, Düsseldorf, FRG) reported on a development of high strength martensite. They have shown that the age hardening of coherent intermetallic precipitates is a very effective way to obtain such martensites. In the last paper of the session *J. B. Vogt* and his coauthors (Universite de Lille, France) discussed the influence of nitrogen on the low temperature stress induced martensitic transformation of stainless steel.

In the workshop "Residual Austenite and Measurement Techniques" held by *I. Schmidt* and in five additional posters, interesting aspects on the development of steels were discussed in detail.

The session on transformations in Mn-, Ti-, Zr-alloys and ceramics was led off by *H. Warlimont* and coworkers (Vacuumschmelze Hanau, FRG). They gave an overview of displacive transformation phenomena in high-T_c-superconductors. The lecture by *G. Vogl* and coauthors (Universität Wien, Austria) dealt with the martensitic phase transition and soft phonons in the pure metals Ti and Zr. *M. Humbert* and coworkers (University of Metz, France) explained a simulation model for the texture transformation which occurs during the martensitic $\alpha-\beta$ transformation of Zr sheets. The fractal aspects of the martensitic transformation in Zirconia were discussed by *W. Wunderlich* (MPI-Düsseldorf, FRG) who made special reference to the study of fractal geometry as a new method for the characterization of microstructures. *S. Schmauder* (MPI Stuttgart, FRG) discussed the nucleation of the martensitic transformation of ZrO_2 in the system Al_2O_3-ZrO_2 before *M. Ellner* (MPI Stuttgart, FRG) closed the session by describing the structure of the high temperature phase $Mn_{0.8}Al$ (h) and the martensitic transformation of this phase to Mn_5Al_8.

The last contribution of the conference was the presentation of an educational film by *S. Keller* (Gewerbeschule Hamburg, FRG) and *J. F. Edgar* (Stockport College of Technology, England) in which the crystallographic characteristics of the martensitic transformation in steels were shown with hard sphere models.

The conference was an exciting and important meeting and provided an excellent opportunity for researchers from academic institutions and industry to meet and discuss problems and aspects of martensitic transformation.

Composites and Particle Technology in Las Vegas

By Wolfgang A. Kaysser *

The 118th TMS Annual Meeting and Joint TMS/SME (The Minerals, Metals and Materials Society/Society of Metallurgical Engineering) Exhibition from February 27 to March 2, 1989 in Las Vegas, Nevada, USA confirmed the growing importance of particulate technology as the major production route to new high performance materials. It is increasingly accepted that the required property combinations such as high temperature strength, creep resistance and toughness at low temperatures are not achievable in mono-

[*] Dr. W. A. Kaysser
Max-Planck-Institut für Metallforschung
Institut für Werkstoffwissenschaften
Pulvermetallurgisches Laboratorium
Heisenbergstraße 5, D-7000 Stuttgart 80 (FRG)

lithic materials and tailored composite microstructures are needed.

Many advanced materials such as intermetallics, ceramic matrix composites and to a lesser extent metal matrix composites suffer from low fracture toughness. New micromechanics models of composite toughening, presented at the conference, require microstructures which permit toughening through the removal of weakly bonded fibers and the bridging of strongly bonded ductile particles. Titanium aluminides are a nice example of attempts to improve the properties of a monolithic base, e.g. Ti_3Al, by introducing stiffening particulates (SiC) which also enhance creep properties, and second phase ductile inclusion (Nb) which results in an increased toughness at lower temperatures. Other intermetallics such as advanced nickel-aluminide alloys have been recognized as potential composite matrix materials for elevated temperature structural applications. The usefulness of monolithic nickel-aluminide single phase material itself, however, is becoming increasingly doubtful due to a combination of limitations in room temperature formability, and creep, oxidation and pest resistance. Reinforced nickel-aluminide alloys should, instead, form a composite with low density, high tensile strength and acceptable creep resistance.

Typical examples of new materials tailored by particulate technology were presented in sessions such as "Light Weight Alloys for Aerospace Applications". Almost all presentations dealt with materials produced from rapidly solidified or mechanically alloyed powders. Major interest focussed in intermetallics on Ti_3Al, TiAl and NiAl compounds or highly modified multiphase Ni-Al composites. In addition, P/M magnesium alloys were shown to be of growing interest because of their low density. Insufficient mechanical performance and corrosion resistance of coarse grained materials has restricted their application up to now. Rapid solidification leads to a substantial refinement of the microstructure, yielding a considerable increase in strength.

Forming methods for materials with rapidly solidified microstructures or composite nature include powder processing, such as particulate liquid infiltration, melt oxidation or mushy state mixing, hot isostatic pressing, forging, rolling and extrusion as well as spray forming or reactive liquid phase sintering. Developments in these processing techniques were emphasized strongly.

Multiphase composites are far from equilibrium, hence, detrimental chemical reactions between the different phases, in particular between the reinforcement and the matrix, can rapidly degrade the strength of the composite. Attempts to solve these problems include variation of the processing parameters to suppress additional intermetallic phases forming at the interfaces, for example in TiB_2/NiAl composites. In most cases coating of the reinforcing phases is necessary to prevent or slow the interface reactions. Coating of SiC fibers or particulates with TiB_2, TiC and Al_2O_3 is used in nickel aluminides and titanium aluminides. Systems such as Ti_3Al and TiB_2 containing coated SiC create a large number of non-equilibrium heterophase boundaries. The prediction of phase stabilities at these interfaces from thermodynamic data and the definition of rules on the time interval of heterophase compatibility from kinetic evaluations (with respect to the mechanical properties) will be of future importance.

Since many of the advanced composites are intended to be used at elevated temperatures, creep becomes a major issue of composite materials characterization. Materials in which the reinforcements are small enough to act as dispersoids, affecting the creep properties, can be treated by the classical microstructural hardening theory. Materials in which reinforcements are large and interact with the matrix elements must be understood in terms of continuum mechanics. Complimentary approaches are needed to understand the creep properties of these materials, for example a mechanics approach that focusses on the load transfer between the matrix and the fiber, and a mechanisms approach that focusses on the interaction of moving dislocations and gliding grain boundaries with larger particles such as fibers. For very high volume fractions of reinforcements the material can almost be locked against creep due to the high constraint levels generated. Lengthy periods of transient response can occur and tertiary behavior can develop due to the failure of the reinforcements. Especially serious consideration was given to superplastic flow in tensile stress loaded metal matrix composites annealed under thermal cycling. The inequality of the thermal expansion coefficients of metal matrix and reinforcement results in very high tensile elongation at low strain rates and low stresses.

It is understood that the expensive powder technology processing of these advanced composites pays off only for elaborate materials designed for the highest performance. This raises the question of the economical viability, i.e. to what extent these materials will be used in applications other than special tasks such as the NASP (National Aero Space Plane) or the former SDI program. It should be noted, however, that the spin-off result of high level targets in materials science for broader applications has been much greater than in other research areas. The use of SiC reinforced aluminum alloys in the pistons of diesel engines in Japan may be nothing other than a first glimpse of the abundant possible applications of these advanced multiphase composites.

The session on the injection molding of powdered metals and ceramics showed the increasingly detailed understanding of this novel powder forming process. Major concerns were the influence of particle size distributions on viscosity, formability and debindering time. Feedstock consisting of spherical 316L stainless steel powder and a polymer binder showed a trend of increasing viscosity with decreasing particle spacing and with a decreasing ratio of particle spacing to particle size. For a number of alloys it is now obvious, however, that second phases forming a liquid during sintering need to be present to achieve full density products after the sintering of the debindered greens. A typical example are injection molded nickel aluminides.