Japanese Aerospace Literature
This month: *Microstructure and Aluminum Alloys*

A95-35412 Elaboration of symmetric functionally gradient materials of the Al_2O_3/TiC/Ni/TiC/Al_2O_3 system. Z. LI, K. TANIHATA, and Y. MIYAMOTO (Osaka Univ., Ibaraki, Japan), *FGM 94; Proceedings of the 3rd International Symposium on Structural and Functional Gradient Materials*, Swiss Federal Inst. of Technology, Lausanne, Switzerland, Oct. 10–12, 1994 (A95-35401 09-23), Lausanne, Switzerland, Presses Polytechniques et Universitaires Romandes, 1995, pp. 109–114. 8 Refs. Documents available from Aeroplus Dispatch.

Symmetric functionally gradient materials of the Al_2O_3/TiC/Ni/TiC/Al_2O_3 and Al_2O_3-30 wt. pct TiC/TiC/Ni/TiC/30 wt. pct TiC-Al_2O_3 were fabricated by SHS/HIP. Use of conventional additives such as MgO and Mo_2C were useful to control the gradual change of microstructures. Strong compressive residual stress as high as 200–300 MPa was induced in the outer layers due to the compositionally symmetric structures, resulting in remarkable reinforcement of mechanical properties of the outer ceramics. Moreover, new intelligent functions such as flaw tolerance and preferential crack propagation in a safe direction appeared. The symmetric gradient structure can create higher order functions than inherent material properties. (Author)

A95-35402 Microstructural characterization of metal/ceramic functionally gradient materials. R. WATANABE, J. TAKAHASHI, and A. KAWASAKI (Tohoku Univ., Sendai, Japan), *FGM 94; Proceedings of the 3rd International Symposium on Structural and Functional Gradient Materials*, Swiss Federal Inst. of Technology, Lausanne, Switzerland, Oct. 10–12, 1994 (A95-35401 09-23), Lausanne, Switzerland, Presses Polytechniques et Universitaires Romandes, 1995, pp. 3–8. 5 Refs. Documents available from Aeroplus Dispatch.

The quantification of microstructure of powder metallurgically processed functionally gradient materials was carried out with particular emphasis on the microstructural connectivity involved within a single material two-dimensional measurements on the cross section, serial sectioning analysis, and packing simulation were employed for the microstructural characterization. The microstructural transition was quantified using topological parameters (Betti number, genus, and interface curvature) and in the light of percolation analysis. The relation between the multiconnectivity of the phases and their percolation cluster formation is discussed on the basis of the experimental and simulation results. (Author)

A95-34680 Polytypes, grain growth, and fracture toughness of metal boride particulate SiC composites. H. TANAKA and N. IYI (National Inst. for Research in Inorganic Materials, Tsukuba, Japan), *American Ceramic Society, Journal* (ISSN 0002-7820), Vol. 78, No. 5, 1995, pp. 1223–1229. 29 Refs. Documents available from Aeroplus Dispatch.

To understand the relation between microstructure and toughening behavior in SiC materials, NbB_2, Ta_2, TiB_2, and ZrB_2 particulate SiC *y* composites were fabricated with pressureless sintering. In the composites, beta (cubic)-SiC powder was used as starting material for the matrix. The beta-SiC powder transformed to alpha (noncubic) phase during sintering. The transformation, the behavior of which was influenced by the existence of metal boride particles, was accompanied by normal or exaggerated grain growth. The metal boride particles suppressed large-scale exaggerated grain aspect ratio of the SiC grains. Increase in the fracture toughness of the composites was observed when the grain size and the aspect ratio of the SiC grains increased together. The toughening behavior is discussed based on a grain bridging mechanism. (Author)

A95-34584 Effects of ZrO_2 addition on microstructure and mechanical properties of $MoSi_2$. Y. SUZUKI, T. SEKINO, and K. NIIHARA (Osaka Univ., Ibaraki, Japan), *Scripta Metallurgica et Materialia* (ISSN 0956-716X), Vol. 33, No. 1, 1995, pp. 69–74. 19 Refs. Documents available from Aeroplus Dispatch.

An effort is made to improve the mechanical properties of $MoSi_2$ by means of a novel approach involving in situ crystallization of the glassy SiO_2 grain boundary phase by addition of ZrO_2. The 3Y-ZrO_2-added $MoSi_2$-based composited thus obtained consisted of an $MoSi_2$ matrix, well-crystallized $ZrSiO_4$, as well as Mo(less than 5)Si_3C(less than 1), and nonreacted tetragonal ZrO_2. The 3Y-ZrO_2 addition was able to enhance room-temperature strength and fracture toughness, due to the decrease of the brittle SiO2 glassy phase at grain boundaries.

A95-34049 Possibility of InP-based 2-dimensional photonic crystal—An approach by the anodization method. T. BABA and M. KOMA (Yokohama National Univ., Japan), *Japanese Journal of Applied Physics, Part 1* (ISSN 0021-4922), Vol. 34, No. 2B, 1995, pp. 1405–1408. 15 Refs. Documents available from Aeroplus Dispatch.

We have investigated the possibility of InP-based two-dimensional photonic crystal experimentally and theoretically. To fabricate such crystal, we aimed at utilizing triangular rods and holes automatically formed at the surface of (111)A InP substrate by an anodization method. Favorable characteristics are that the rods and holes orient perpendicular to the surface and have submicron width and high aspect ratio. In addition, observed photoluminescence spectra indicated negligibly slow surface recombination at the anodized surface. From the calculation of band diagram, the photonic gap was found for uniform triangular rods. Thus low-damage two-dimensional photonic crystal which controls light emission and propagation in the two-dimensional plane can be realized by controlling the size uniformity and position of rods using the patterned oxide mask. (Author)

A95-32799 Microstructure and mechanical properties of the L1(2)/L2(1) two-phase alloys in the quaternary Co-Al-Ni-Ti system. T. MATANO (Tokyo Inst. of Technology, Yokohama, Japan), Y. KIMURA (Tokyo Inst. of Technology, Japan), S. MIURA, and Y. MISHIMA (Tokyo Inst. of Technology, Yokohama, Japan), *High-temperature ordered intermetallic alloys VI; Proceedings of the Symposium*, Boston, MA, Nov. 28–Dec. 1, 1994. Pt. 2 (A95-32604 08-26), Pittsburgh, PA, Materials Research Society (MRS Symposium Proceedings. Vol. 364), 1995, pp. 1377–1382. 16 Refs. Documents available from Aeroplus Dispatch.

An attempt is made to develop a two-phase alloy consisting of the L1(2) and L2(1) (Heusler) phases in the Co-Al-Ni-Ti quaternary system exhibiting a high elevated temperature strength as well as some room temperature ductility as a new class of heat resisting structural materials. The idea behind this approach is expectations for the L2(1) phase to provide high elevated temperature strength, whereas the L1(2) phase provides some room temperature ductility. Compositional optimization in the room temperature ductility of the L1(2) (Co,Ni)3(Al,Ti) is first carried out and then, based on the result, several L1(2)/L2(1) two phase alloys are designed. It is found that a few to several percent room temperature bend ductility is obtained in such two-phase alloys. (Author)

A95-32778 Solid-solution strengthening effect of vanadium addition to iron-modified L1(2) titanium trialuminides. T. TAKAHASHI and T. HASEGAWA (Tokyo Univ. of Agriculture and Technology, Koganei, Japan), *High-temperature ordered intermetallic alloys VI; Proceedings of the Symposium*, Boston, MA, Nov. 28–Dec. 1, 1994. Pt. 2 (A95-32604 08-26), Pittsburgh, PA, Materials Research Society (MRS Symposium Proceedings. Vol. 364), 1995, pp. 1235–1240. 9 Refs. Documents available from Aeroplus Dispatch.

Two types of Al-Ti-Fe-V quarternary intermetallic compounds have been prepared by arc melting under Ar atmosphere. Their compositions were nominally $Al_{66}Ti_{25}Fe_6V_3$ and $Al_{66}Ti_{25}Fe_3V_6$. These alloys are based on the iron-modified titanium trialuminide with L1(2) cubic structure. Vanadium addition up to about 6 mol pct did not destroy the cubic symmetry, and L1(2) solid solution compounds were produced in these two Al-Ti-Fe-V quarternary alloys. Microstructure and mechanical properties have been investigated. It has been demonstrated that vanadium addition to iron-modified L1(2) titanium trialuminides can enhance their strength. (Author)

A95-32727 Phase stability, microstructure and mechanical properties in the multi-phase alloys based on the L1(2)-Ni_3(Al,Be). T. MATSUO (Tokyo Inst. of Technology, Yokohama, Japan), H. HOSODA (Washington, Univ., Seattle), S. MIURA, and Y. MISHIMA (Tokyo Inst. of Technology, Yokohama, Japan), *High-temperature ordered intermetallic alloys VI; Proceedings of the Symposium*, Boston, MA, Nov. 28–Dec. 1, 1994. Pt. 2 (A95-32604 08-26), Pittsburgh, PA, Materials Research Society (MRS Symposium Proceedings. Vol. 364), 1995, pp. 855–860. 5 Refs. Documents available from Aeroplus Dispatch.

Intermetallic alloys based on the L1(2) Ni_3(Al,Be) phase in the ternary Ni-Al-Be system are prepared so that the alloys are multiphase, with the B_2 intermetallic compound NiBe and a Ni primary solid solution denoted as Ni. Such three-phase alloys, Ni-16 to 20 at. pct Al-10 at. pct Be, exhibit good room temperature ductility as measured by four-point bending. To examine the phase stabilities and relations among constituent phases, a vertical section of the ternary system is constructed at a constant 10 at. pct Be mainly by differential thermal analysis. It is found that improvement in room temperature ductility can be achieved by the formation of a fine mixture of constituent phases during invariant reactions during solidification, which is further enhanced by the coexistence of the L1(2) phase formed as the primary solidification phase. (Author)

A95-32681 High temperature creep of alpha-2 Ti-34 mol pct Al polycrystals. H. OIKAWA, T. FUKUDA, and M. OHTSUKA (Tohoku Univ., Sendai, Japan), *High-temperature ordered intermetallic alloys VI; Proceedings of the Symposium*, Boston, MA, Nov. 28–Dec. 1, 1994. Pt. 1 (A95-32604 08-26), Pittsburgh, PA, Materials Research Society (MRS Symposium Proceedings. Vol. 364), 1995, pp. 517–522. 6 Refs. Documents available from Aeroplus Dispatch.

Constant-stress compressive creep tests were carried out on an Al-rich alpha2 single-phase material, which had equiaxed-grains of 60 gm in grain size, at 1050–1250 K under 100–500 MPa. The type of the primary creep stage and the microstructures developed during creep depend greatly on the creep condition. The minimum creep-rate, however, can be represented by one set of parameters over the whole range of experimental condition. The stress exponent is 5.0 +/– 0.2 and the (modulus-compensated) activation energy is 360 +/– 10 kJ/mol. The Dorn-type plot of the minimum creep rate reveals that the normalized creep strength of fine-grained Ti-34 mol pct Al is not greatly different from that of disordered solid-solution hardened alloys. (Author)

A95-32628 Reaction process of alpha—gamma massive transformation in Ti-rich TiAl alloy. T. KUMAGAI; E. ABE (National Research Inst. of Metals, Tsukuba, Japan); M. TALEYAMA (Tokyo Inst. of Technology,

Japan), and M. NAKAMURA (National Research Inst. of Metals, Tsukuba, Japan), *High-temperature ordered intermetallic alloys VI; Proceedings of the Symposium*, Boston, MA, Nov. 28–Dec. 1, 1994. Pt. 1 (A95-32604 08-26), Pittsburgh, PA, Materials Research Society (MRS Symposium Proceedings. Vol. 364), 1995, pp. 181–186. 15 Refs. Documents available from Aeroplus Dispatch.

Reaction sequence of the massive transformation from the high-temperature alpha-Ti phase gamma(m) to the gamma-TiAl phase in a Ti-48 at. pct Al alloy has been examined in terms of optical and TEM. Both transformed and untransformed regions were macroscopically observed in the sample quenched from the high-temperature alpha phase field, when the sample was held there for a extended period of time prior to quenching. The transformed region consists of randomly oriented fine γ single phase grains, in which many thermal antiphase domains (TAPDs), together with a number of stacking faults were observed. In contrast, the untransformed region comprises extremely fine lamellae of the gamma and alpha2-Ti_3Al phases, and the γ plates were found to run through the TAPDs caused by alpha–alpha2 ordering. Subsequent aging at 1273 K causes the microstructure change in the untransformed region from alpha2/gamma lamellae to gamma/gamma lamellae spontaneously and expands the gamma(m) region. These observations suggest that the alpha–gamma(m) transformation proceeds through formation of fine gamma plates. (Author)

A95-32605 Gamma titanium aluminide alloys. M. YAMAGUCHI, H. INUI, M. MATSUMURO, and Y. SHIRAI (Kyoto Univ., Japan), *High-temperature ordered intermetallic alloys VI; Proceedings of the Symposium*, Boston, MA, Nov. 28–Dec. 1, 1994. Pt. 1 (A95-32604 08-26), Pittsburgh, PA, Materials Research Society (MRS Symposium Proceedings. Vol. 364), 1995, pp. 3–16. 66 Refs. Documents available from Aeroplus Dispatch.

Extensive progress and improvements have been made in the science and technology of gamma TiAl alloys within the last decade. In particular, our understanding of their microstructural characteristics and property/microstructure relationships has been substantially deepened. Based on these achievements, various engineering two-phase gamma alloys have been developed and their mechanical and chemical properties have been assessed. At the same time, recent basic studies on the mechanical properties of two-phase gamma alloys, in particular with a controlled lamellar structure have provided a considerable amount of fundamental information on the deformation and fracture mechanisms of the two-phase gamma alloys. The results of such basic studies are incorporated in the recent alloy and microstructure design of two-phase gamma alloys. In this paper, such recent advances in the research and development of the two-phase gamma alloys and industrial involvement are summarized. (Author)

A95-31497 Development of high-strength aluminum alloys by mesoscopic structure control. K. OSAMURA, O. KUBOTA, P. PROMSTIT, H. OKUDA, S. OCHIAI (Kyoto Univ., Japan), K. FUJII, J. KUSUI, T. YOKOTE, and K. KUBO (Toyo Aluminum, Research and Development Lab., Japan), *Metallurgical and Materials Transactions A—Physical Metallurgy and Materials Science* (ISSN 1073-5623), Vol. 26A, No. 6, 1995, pp. 1597-1599. 6 Refs. Documents available from Aeroplus Dispatch.

Al alloys whose tensile strength exceeds 900 MPa, and whose elongation is greater than 1 pct, have been produced by controlling mesoscopic structure. Cold isostatic pressing was followed by hot-pressing and 20:1-reduction hot extrusion, attention is given to the chemical composition and mechanical properties of these alloys.

A95-30971 Effect of surface treatment for metals by transferred arc. Y. ITOH, M. SAITOH, K. HONDA, and M. MIYAZAKI (Toshiba Corp., Heavy Apparatus Engineering Lab., Yokohama, Japan), *Japan Society of Materials Science, Journal* (ISSN 0514-5163), Vol. 44, No. 498, 1995, pp. 303–308. In Japanese. 7 Refs. Documents available from Aeroplus Dispatch.

Low pressure plasma spraying is well suited for high-temperature corrosion-resistant coatings of gas turbine components. In this coating process, coating adhesion is an important problem, and so surface roughness and cleaning achieved by the transferred arc treatment with negative substrate polarity have to be investigated in order to improve the adhesion. In this paper, an experimental investigation was conducted to clarify the effect of the transferred arc treatment on the bonding strength of sprayed coatings. As a result, it was verified by SEM observations that surface cleaning and surface roughening could be made by the transferred arc treatment in the case of IN738LC, SUS304, tungsten, and copper. It was also confirmed that grit-blasting before the transferred arc treatment was effective for the uniformity of surface cleaning and toughening, which means an improvement in the adhesion of the sprayed coating. It was confirmed that the surface roughness achieved by the transferred arc treatment could be evaluated by the thermal conduction parameter c × rho × (Tm − T0), where c = specific heat, rho = density, Tm = melting point, and T0 = initial temperature. (Author)

A95-30885 Effect of water vapor processing on microstructure and superconducting property of high-Tc superconductors $YBa_2Cu_3O(x)$ and Bi(1.85)Pb(0.35)Sr(1.90)Ca(2.05)Cu(3.05)O(y). X. ZHENG, N. YAMAGUCHI, H. KURIYAKI, and K. HIRAKAWA (Kyushu Univ., Fukuoka, Japan), *Japanese Journal of Applied Physics*, Pt. 1 (ISSN 0021-4922), Vol. 34, No. 1, 1995, pp. 93–97. 5 Refs. Documents available from Aeroplus Dispatch.

The effect of water vapor on the microstructure and superconducting properties of high-temperature (high-Tc) superconductors is investigated using polycrystalline $YBa_2Cu_3O(x)$ and I(1.85)Pb(0.35)Sr(1.90)Ca(2.05)Cu(3.05)O(y). The superconductors are sintered in atmospheres of H_2O-O_2 and H_2O-O_2-Ar, respectively, instead of O_2. Crystal growth, especially that around grain boundaries, is greatly enhanced by water-vapor processing. As a result, the transport critical current density Jc is considerably enhanced. (Author)

A95-30750 High strain rate superplasticity of Si_3N_4 whisker reinforced 7075 alloy matrix composite fabricated by squeeze casting. S.-W. LIM and Y. NISHIDA (Nagoya, National Industrial Research Inst., Japan), *Scripta Metallurgica et Materialia* (ISSN 0956-716X), Vol. 32, No. 11, 1995, pp. 1821–1825. 15 Refs. Documents available from Aeroplus Dispatch.

The successful production by squeeze casting and hot extrusion of alpha-Si_3N_4 whisker-reinforced 7075 aluminum alloy composite exhibiting superplasticity is reported. The composite exhibited a total elongation of 260 percent at strain rates 0.18/s at 773 K. The superplasticity occurred in the wide range of strain rate from 0.1/s to 1/s. The superplasticity occurred in the industrially useful whisker volume fraction range of 20–30 percent.

A95-30747 High temperature mechanical properties of a beta-Si_3N_4 whisker reinforce aluminium alloy composite produced by squeeze casting. I. TOCHIGI (Kanagawa High Technology Foundation, Kawasaki, Japan), T. IMAI (Nagoya, National Industrial Research Inst., Japan), and K. Ai (Kanagawa, Industrial Research Inst., Yokohama, Japan), *Scripta Metallurgica et Materialia* (ISSN 0956-716X), Vol. 32, No. 11, 1995, pp. 1801–1806. 13 Refs. Documents available from Aeroplus Dispatch.

The tensile strength at elevated temperature and the superplastic characteristics of a beta-Si_3N_4 whisker-reinforced aluminum alloy composite fabricated by squeeze casting are studied along with the superplastic deformation mechanism of the composite. The composite exhibits tensile strengths of about 400 MPa at room temperature and about 250 MPa at 773 K. The m value of the composite pulled at 818 K is 0.33 in the strain rate range from 0.02 up to 1.0/s. The total elongation of the composite becomes about 173 percent at the strain rate of 0.02/s even in the case of the high volume fraction of 0.25. No reaction product on the whisker surface after matrix removal was detected except AlN. The fracture surface of the composite includes the melt matrix and small filaments, showing that interfacial sliding should promote high strain rate superplasticity in addition to fine grain boundary sliding.

A95-30736 High strain rate superplasticity of TiC particulate reinforced magnesium alloy composite by vortex method. S.-W. LIM, T. IMAI, Y. NISHIDA (Nagoya, National Industrial Research Inst., Japan), and T. CHOH (Nagoya Univ., Japan), *Scripta Metallurgica et Materialia* (ISSN 0956-716X), Vol. 32, No. 11, 1995, pp. 1713–1717. 14 Refs. Documents available from Aeroplus Dispatch.

The superplastic characteristics of a Mg-5 pct Zn/TiCp composite, fabricated by vortex method, extrusion, and hot-rolling, were investigated. The strain rate sensitivity of the composite with Vf = 0.20 is found to be about 0.33. The hot-rolled composite exhibited a total elongation of 340 percent at strain rates of 0.067/s at 743 K. The fracture surface of the composite showed fibrous features, indicating the presence of partial melting, since the composite was deformed apparently above the solidus temperature of the Mg-5 pct Zn matrix. The presence of the liquid phase can enhance high strain rate superplasticity phenomenon in magnesium-based composite.

A95-28838 Amorphization promoted by mechanical alloying of aluminum-rich Al-Ti-Fe mixed powders. S. SAJI (Toyama Univ., Japan), Y. NEISHI, H. ARAKI, Y. MINAMINO (Osaka Univ., Japan), and T. YAMANE, (Hiroshima Inst. of Technology, Japan), *Metallurgical and Materials Transactions A—Physical Metallurgy and Materials Science* (ISSN 1073-5623), Vol. 26A, No. 5, 1995, pp. 1305–1307. 15 Refs. Documents available from Aeroplus Dispatch.

The promotion of amorphization by mechanical alloying in aluminum-rich Al-12 at. pct Ti-Fe mixed powders due to an increase of iron content up to about 7 at. pct was investigated experimentally using X-ray diffraction, transmission electron microscopy, and chemical analysis. The results obtained indicate that almost complete amorphization by mechanical alloying is achieved with coexistence of about 12 at. pct Ti and 7 at. pct Fe. Details of the experimental procedure are discussed.

A95-28829 Fracture characteristics of Ti-6Al-4V and Ti-5Al-2.5Fe with refined microstructure using hydrogen. M. NIINOMI, T. KOBAYASHI, O. TORIYAMA (Toyohashi Univ. of Technology, Japan), B. Gong (Chinese Academy of Sciences, Inst. of Metal Research, Shenyang, China), Y. Ohyabu (Sumitomo Metals Industries Co., Jyouetsu, Japan), *Metallurgical and Materials Transactions A—Physical Metallurgy and Materials Science* (ISSN 1073-5623), Vol. 26A, No. 5, May 1995, pp. 1141–1151. 17 Refs. Documents available from Aeroplus Dispatch.

The hydrogenation behavior of Ti-6Al-4V with starting microstructures of coarse equiaxed and coarse Widmanstatten alpha was investigated under a hydrogen pressure of 0.1 MPa at temperatures between 843 and 1123 K. The hydrogen content was determined as a function of hydrogenation time, hydrogenation temperature, and hydrogen flow rate. The mechanical properties and fracture toughness of Ti-6Al-4V and Ti5Al-2.5Fe subjected to thermochemical processing (TCP) and below beta (H) transus hydrogenation (BTH) were then investigated. Both conventional TCP and BTH result in a increase in yield strength, ultimate tensile strength, and elongation; however, the BTH gives the best balance between strength and elongation. The TCP-treated Ti-6Al-4V shows smaller fracture toughness compared with the unprocessed material, while TCP-treated Ti-5Al-2.5Fe shows greater fracture toughness compared with the unprocessed material. The BTH treatment results in an improvement in fatigue strength in both Ti-6Al-4V and Ti-5Al-2.5Fe. (Author)