Japanese Aerospace Literature This month: *Aluminum Alloys*

A95-33503 Fabrication of an AlN particulate aluminium matrix composite by a melt stirring method. E. TAHERI-NASSAJ, M. KOBASHI, and T. CHOH (Nagoya Univ., Japan), *Scripta Metallurgica et Materialia* (ISSN 0956-716X), Vol. 32, No. 12, 1995, pp. 1923–1929. 19 Refs. Documents available from Aeroplus Dispatch.

The incorporation of as-received and oxidized AlN particles into molten aluminum was investigated experimentally using a melt stirring method. It is found that the addition of Mg and Li facilitates the incorporation of AlN particles into the melt by improving their wettability. The incorporation of AlN particles was also accelerated by increasing the process temperature; the mixing time, however, was increased in a nitrogen atmosphere. The addition of Mg also improved the strength of the composites.

A95-33502 Superplasticity of whisker reinforced 2024 aluminum alloy composites 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. 12, 1995, pp. 1911–1915. 14 Refs. Documents available from Aeroplus Dispatch.

In the study reported here, alpha-Si_3N_4 and beta-SiC whisker reinforced 2024 aluminum alloy composites exhibiting superplasticity were produced by squeeze casting followed by hot extrusion. The superplastic behavior of the composites was observed at strain rates between 0.09 and 0.40/s. Superplasticity was observed in composites with whisker volume fractions between 20 and 30%, which are typical of industrial applications.

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)

A95-31725 Friction welding of aluminum alloy and carbon steel using insert metal. K. OGAWA (Osaka Inst. of Technology, Japan), H. OCHI, K. YASUMI, and T. OHNISHI (Osaka Prefecture, Univ., Sakai, Japan), *Osaka Prefecture University*, Bulletin, Series A—Engineering and Natural Sciences (ISSN 0474-7844), Vol. 43, No. 2, 1994, pp. 113–117. 4 Refs. Documents available from Aeroplus Dispatch.

The friction welding of low-weldability 2017 aluminum alloy and S45C carbon steel was conducted using the insert metals of A1050 industrial pure aluminum and of various aluminum alloys produced specially for this study. From the tensile tested results of the welded joints, it was clarified that the aluminum alloys were superior to A1050 aluminum as an insert metal because of the high joint strength. In particular, the high tensile strength of 380 MPa was obtained using an aluminum alloy containing 3% magnesium. (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%, 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.

A95-30750 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% at strain rates 0.18/s at 773 K. The superplasticity occurred in the wide range of strain rate from 0.1 to 1/s. The superplasticity occurred in the industrially useful whisker volume fraction range of 20–30%.

A95-30737 Absorption and desorption of hydrogen in Fe-40Al intermetallic. Y. YANG and S. HANADA (Tohoku Univ., Sendai, Japan), *Scripta Metallurgica et Materialia* (ISSN 0956-716X), Vol. 32, No. 11, 1995, pp. 1719–1724. 15 Refs. Documents available from Aeroplus Dispatch.

The kinetics of hydrogen diffusion is studied based on the results of hydrogen content measurements in B2 FeAl after a heat treatment. A temperature-programmed hydrogen release test was also undertaken to investigate the existing states of hydrogen in FeAl. It is shown that the hydrogen concentration in an Fe-40Al single crystal can be decreased significantly by heat treatment in vacuum, while the hydrogen content increases significantly when the crystal is exposed in air at room temperature. An expression is given for the change in hydrogen content. The estimated hydrogen diffusivity for the Fe-40Al single crystal at room temperature is about 10 exp-9 sq cm/s. It is shown that hydrogen can be trapped in a vacancy or bonded inside the lattice of the single crystal. Because of the difference instability, two different release temperatures are observed for hydrogen in a vacancy and hydrogen-bonded in the lattice. The lattice hydrogen shows the highest stability.

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.% Ti-Fe mixed powders because of an increase of iron content up to about 7 at.% 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.% Ti and 7 at.% 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), and 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, 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, whereas 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)

A95-26914 Defects formation mechanisms in laser welding and their suppression methods. A. MATSUNAWA (Osaka Univ., Ibaraki, Japan), *ICALEO '94—Laser materials processing; Proceedings of the Conference*, Orlando, FL, Oct. 17–20, 1994 (A95-26907 06-36), Orlando, FL/Bellingham, WA, Laser Institute of America/Society of Photo-Optical Instrumentation Engineers (SPIE Proceedings. Vol. 2500), 1994, pp. 203–209. 4 Refs. Documents available from Aeroplus Dispatch.

The significant problems of laser welding, particularly by a pulsed laser, are formation of various welding defects such as porosity, cracking, and undercutting. To reduce these defects, the authors have developed a special laser with pulse shaping function. The paper describes the effects of pulse shaping on reduction of porosity and weld cracking of spot welding of difficult materials such as Al-alloys and stainless steels. By the selection of optimum pulse shape the defects can be drastically reduced and a sound weld can be obtained. (Author)

A95-26465 Crystal system of rod-shaped precipitates in an Al-1.0 mass pct Mg2Si-0.4 mass pct Si alloy. K. MATSUDA, S. TADA, S. IKENO (Toyama Univ., Japan), T. SATO, and A. KAMIO (Tokyo Inst. of Technology, Japan), *Scripta Metallurgica et Materialia* (ISSN 0956-716X), Vol. 32, No. 8, 1995, pp. 1175–1180. 4 Refs. Documents available from Aeroplus Dispatch.

The crystal lattice of the rod-shaped precipitate in an Al-1.0 mass % Mg2Si-0.4 mass % Si alloy was investigated using the electron diffraction technique. The crystal lattice of the precipitate is determined to be a simple hexagonal with a = 0.405 mm and c = 0.67 nm. The orientation relationship between the precipitate and the matrix is (−1 2 −1 0)//(001)m and −1 2 −1 0-line-p//0 0 1-line-m. The angle between the 0 0 0 1-line-p and the 1 0 0-line-m is

about 20 deg with a rotation axis of −1 2 −1 0-line-p. Energy-dispersive X-ray analysis shows that the metastable phase in the excess Si alloy is composed of silicon, aluminum, and magnesium.

A95-24233 High strain rate superplasticity of TiB_2 particulate reinforced aluminium alloy composite. T. IMAI (Nagoya, National Industrial Research Inst., Japan), G. L'ESPERANCE, B. D. HONG (Ecole Polytechnique, Montreal, Canada), and Y. TOZAWA (Daido Inst. of Technology, Nagoya, Japan), *Journal of Materials Science Letters* (ISSN 0261-8028), Vol. 14, No. 5, 1995, pp. 373–376. 11 Refs. Documents available from Aeroplus Dispatch.

The superplastic deformation mechanisms for ceramic whisker or particulate reinforced aluminum alloy composites are investigated. Fabrication processing steps to produce high strain rate superplasticity (HSRS) in TiB_2 particulate reinforced aluminum alloy composite are established. It is concluded that repeated hot-rolling and reheating after extrusion can produce HSRS in TiB_2r/2124, TiB_2f/2014, and TiB_2/6061 Al composites, and that the main superplastic deformation mechanisms are fine grain boundary sliding and interfacial sliding involving a semiliquid phase.

A95-20106 Temperature-dependence mechanism of tensile strength of Si-Ti-C-O fiber-aluminum matrix composites. S. OCHIAI, M. HOJO, K. OSAMURA (Kyoto Univ., Japan), K. MATSUNAGA, Y. WAKU, and T. YAMAMURA (Ube Industries, Ltd., Japan), *Metallurgical and Materials Transactions A—Physical Metallurgy and Materials Science* (ISSN 1073-5623), Vol. 26A, No. 3, 1995, pp. 647–652. 22 Refs. Documents available from Aeroplus Dispatch.

The mechanism for the temperature dependence of the tensile strength of unidirectional hybrid type Si-Ti-C-O fiber-reinforced Al-matrix composite, in which SiC-particles are dispersed in the matrix, is discussed, focusing on the temperature dependencies of the stress concentration arising from broken fibers and critical length and their effects on the composite strength, by means of a shear-lag analysis and a Monte Carlo simulation. The main results are summarized as follows. The softening of the matrix at high temperatures raises the composite strength from the point of decrease in stress concentration; on the other hand, it also reduces strength from the point of increase in critical length, which reduces the stress-carrying capacity of broken fibers over a long distance. The results of the simulation indicated that the hybridization of the composites improved room-temperature and high-temperature strengths through the strengthening of the matrix. (Author)

A95-20105 An investigation of strain hardening and creep in an Al-6061/Al2O3 metal matrix composite. M. FURUKAWA (Fukuoka Univ. of Education, Munakata, Japan), J. WANG (Xian Inst. of Metallurgy and Construction Engineering, China), Z. HORITA, M. NEMOTO (Kyushu Univ., Fukuoka, Japan), Y. MA, and T. G. LANGDON (Southern California, Univ., Los Angeles, CA), *Metallurgical and Materials Transactions A—Physical Metallurgy and Materials Science* (ISSN 1073-5623), Vol. 26A, No. 3, 1995, pp. 633–639. 36 Refs. Documents available from Aeroplus Dispatch.

Experiments were conducted to compare the influence of temperature on the flow and strain-hardening characteristics of an Al-6061 metal matrix composite, reinforced with about 20 vol% of Al_2O_3-based microspheres, with the unreinforced monolithic alloy. At room temperature, the yield stresses and the strain-hardening rates are higher in the composite material in the as-quenched condition and after aging at 448 K for periods of time up to 300 hs. The 0.2% proof stress and the strain-hardening rate decrease with increasing temperature in both materials, but the rate of decrease is faster in the composite, so that the unreinforced monolithic alloy exhibits higher yield stresses and strain-hardening rates at temperatures in the vicinity of 600 K. Under conditions of constant stress at high temperatures, the composite exhibits both a higher creep strength than the monolithic alloy and higher values for the stress exponents for creep. (Author)

A95-20102 The age-hardening characteristics of an Al-6061/Al_2O_3 metal matrix composite. J. WANG (Xian Inst. of Metallurgy and Construction Engineering, China), M. FURUKAWA (Fukuoka Univ. of Education, Munakata, Japan), Z. HORITA, M. NEMOTO (Kyushu Univ., Fukuoka, Japan), Y. MA, and T. G. LANGDON (Southern California, Univ., Los Angeles, CA), *Metallurgical and Materials Transactions A—Physical Metallurgy and Materials Science* (ISSN 1073-5623), Vol. 26A, No. 3, 1995, pp. 581–587. 34 Refs. Documents available from Aeroplus Dispatch.

Experiments were conducted to determine the age-hardening behavior of an Al-6061 metal matrix composite reinforced with about 20 vol% of Al_2O_3 microspheres and prepared using liquid metallurgy processing. The presence of alumina microspheres increases the dislocation density in the matrix of the composite in the as-quenched state; by comparison with the monolithic alloy, this leads to a significant increase in the yield stress in the as-quenched and unaged condition. There was no evidence for any significant acceleration in the aging process in the composite material: both materials attain similar peak-aged conditions after essentially the same aging times. The microstructures of the composite and the monolithic alloy are similar in the peak-aged condition, with a high density of fine needlelike beta-double-prime precipitates and, in the over-aged condition, with a reasonably homogeneous distribution of the rod-shaped beta-prime phase. (Author)

A94-28472 Fabrication and properties of TiC particulate reinforced aluminium alloy composite foils. T. IMAI (Government Industrial Research Inst., Nagoya, Japan), G. L'ESPERANCE, B. D. HONG (Montreal, Ecole Polytechnique, Canada), and Y. TOZAWA (Daido Inst. of Technology, Nagoya, Japan), *Journal of Materials Science Letters* (ISSN 0261-8028), Vol. 13, No. 13, 1994, pp. 963–965. 10 Refs. Documents available from Aeroplus Dispatch.

This study aims to establish how to fabricate a foil of discontinuous ceramic-fiber-reinforced Al-alloy composite, to evaluate the mechanical properties of the composite foil, and to determine whether the foil could have superplasticity. Titanium carbide particles with average particle size of 1.0 μ were used as reinforcement. The experiments show that repeated hot rolling and reheating makes it capable of fabricating a foil of TiC particulate-reinforced Al-alloy composites which exhibit high tensile strengths of about 450 MPa and which could produce total elongation of about 200% at a high strain rate of 0.6/s. Fine grain boundary sliding is concluded to be the primary superplastic deformation mechanism.

A95-16966 Readily superplastic forging at high strain rates in an aluminum-based alloy produced from nanocrystalline powders. K. TAKETANI, A. UOYA, K. OHTERA, T. UEHARA (Yoshida Kogyo, Technical Research Labs., Kurobe, Japan), K. HIGASHI (Osaka Prefecture, Univ., Sakai, Japan), A. INOUE, and T. MASUMOTO (Tohoku Univ., Sendai, Japan), *Journal of Materials Science* (ISSN 0022-2461), Vol. 29, No. 24, 1994, pp. 6513–6517. 5 Refs. Documents available from Aeroplus Dispatch.

A high-strain-rate superplasticity at strain rates from 0.1 to 1/s (which was many orders of magnitude higher than the strain rates in typical commercial superplastic alloys) was found in a new aluminum-based crystalline alloy, as-extruded Al-Ni-Mm crystalline and Al-Ni-Mm-Zr crystalline alloys (Mm = misch metal) fabricated by warm consolidation of their amorphous or nanocrystalline powders. The alloys were developed with very fine grained structures less than 100 nm in size, with a uniform distribution of both the Al_3Mm and the Al_3Ni particulates which were 70 nm in diameter. As a result of these specific microstructures, these alloys have superior mechanical properties at room temperature; for example the tensile strength is greater than 800 MPa and the Young's modulus is equal to 96 GPa. As-extruded workpieces of the alloys could be forged superplastically at a commercial production speed (less than 1 s) into complicated components with a con-rod shape, which exhibited good postdeformation mechanical properties. (Author)

A95-16921 Behaviour of impurity hydrogen in light alloys. G. ITOH, M. KANNO, and H. OKADA (Tokyo, Univ., Japan), *Recent developments in light metals; Proceedings of the International Symposium*, Toronto, Canada, Aug. 20–25, 1994 (A95-16901 03-23), Montreal, Canada, Canadian Institute of Mining, Metallurgy and Petroleum, 1994, pp. 315–329. 27 Refs. Documents available from Aeroplus Dispatch.

Two series of newly designed experimental techniques were applied to clarify the behavior of impurity hydrogen in some light alloys. The results revealed that impurity hydrogen segregates on the interface of grain boundary precipitates in aluminum alloys. A new testing machine equipped with an ultrahigh vacuum chamber and mass spectrometer was developed, demonstrating the relationship between hydrogen and fracture in aluminum alloys and a titanium aluminide. (Author)

A95-14572 Effect of high pressure on interdiffusion in Al-Cu-Zn alloys. T. TAKAHASHI (Niihama National College of Technology, Japan), T. YAMANE, T. YAMAMOTO, H. ARAKI, Y. MINAMINO (Osaka Univ., Suita, Japan), and Y. MIYAMOTO (Osaka Univ., Japan), *Zeitschrift fuer Metallkunde* (ISSN 0044-3093), Vol. 85, No. 7, 1994, pp. 492–497. 42 Refs. Documents available from Aeroplus Dispatch.

The interdiffusion coefficients in the alpha fcc phase of the Al-Cu-Zn alloys have been determined under pressures from 0.101 to 2800 MPa in the temperature range from 815 to 860 K. The diffusion coefficients decrease with increasing pressure. The activation energies for the interdiffusion and impurity diffusion increase with pressure. The ratio of the activation volume to the molar volume of aluminum is between 0.96 and 1.05. It is concluded that the diffusion of copper and zinc in the Al-Cu-Zn alloy occurs predominantly by the monovacancy mechanism. (Author)

A95-13959 Effect of temperature on tensile properties of TiAl base alloys. K. HASHIMOTO, S. KAJIWARA, T. KIKUCHI, and M. NAKAMURA (National Research Inst. for Metals, Tsukuba, Japan), *Scripta Metallurgica et Materialia* (ISSN 0956-716X), Vol. 32, No. 3, 1995, pp. 417–422. 20 Refs. Documents available from Aeroplus Dispatch.

The temperature and microstructure dependence of tensile properties is here examined in the room temperature −770 K range for both binary and manganese-containing TiAl alloys. Elongation is noted to rise with increasing temperature up to 470 K in alloys that had been heat-treated at 1550 K. Additional temperature-related effects on tensile properties are noted.

A95-11899 Low-cycle fatigue properties of a SiC whisker-reinforced 2124 Al alloy. M. SASAKI (Nippon Metal Industry Co., Ltd., Sagamihara, Japan), L. LAWSON, and M. MESHII (Northwestern Univ., Evanston, IL), *Metallurgical Transactions A—Physical Metallurgy and Materials Science* (ISSN 1073-5623), Vol. 25A, No. 10, 1994, pp. 2265–2274. 30 Refs. Documents available from Aeroplus Dispatch.

Results are presented from a study of the low-cycle fatigue leading to failure of specimens of a P/M 2124 Al alloy reinforced with 20 vol% SiC whiskers. Microcrack size distributions and growth data were obtained at various stages of fatigue via a surface-replica technique. Continued cycling led to the formation of microcracks that were lost through linkage with other cracks.