Japanese Aerospace Literature This month: *Magnesium Alloys*

A95-39504 Effect of Zr addition on superplastic deformation of the Mg-8 percent Li eutectic alloy. W. FUJITANI (Osaka Univ., Suita, Japan), K.-I. HIGASHI (Osaka Univ., Suita; Sharp Co., Ltd., Tenri, Japan), N. FURUSHIRO, and Y. UMAKOSHI (Osaka Univ., Suita, Japan), *Japan Institute of Light Metals, Journal* (ISSN 0451-5994), Vol. 45, No. 6, 1995, pp. 333–338. In Japanese. 10 Refs. Documents available from Aeroplus Dispatch.

The effect of Zr addition on superplastic deformation has been investigated using Mg-8 mass percent Li eutectic alloys containing 0 or 0.2 mass percent Zr. The (alpha + beta) eutectic structure of these alloys was controlled to produce a fine and equiaxed grain structure by a thermomechanical treatment. Recrystallized structures were refined by the Zr addition. The elongation higher than 500% was obtained for the fine-grained specimen. These specimens showed larger values of m, which decreased with structural changes during superplastic deformation. During the superplastic deformation, refinement of the beta grains was observed, while grain growth of the alpha grains was found. Improvement of superplastic behavior due to the Zr addition was considered to be caused by both finer grain structure before loading and suppression of dislocation process by solute atoms of Zr, which result in both uniform deformation and dynamic recrystallization. (Author)

A95-39503 Fabrication and spontaneous infiltration process analysis of particulate reinforced Mg composites. H. KANEDA (Nagoya Univ., Suzuki Motor Corp., Hamamatsu, Japan) and T. CHOH (Nagoya Univ., Japan), *Japan Institute of Light Metals, Journal* (ISSN 0451-5994), Vol. 45, No. 6, 1995, pp. 321–326. In Japanese. 11 Refs. Documents available from Aeroplus Dispatch.

The fabrication method of particulate reinforced magnesium matrix composites using spontaneous infiltration phenomenon was developed. By premixing the infiltration agent to reinforcement powder, magnesium melt infiltrated into the powder spontaneously even under pure argon gas atmosphere at 973 K. In this work, fundamental experiments were carried out to find out the conditions under which spontaneous infiltration can occur in the pure Mg-SiCp system, using SiO_2 powder as an infiltration agent. Microstructure observation and XRD analysis were also carried out to make clear the infiltration mechanism. The spontaneous infiltration depends both on SiCp diameter and on SiO_2 content. The threshold SiO_2 content decreases with increasing SiCp diameter. Microstructure observation revealed no uninfiltrated part and the formation of two kinds of reaction products. In the composites MgO, Mg_2Si, and no SiO_2 were detected by XRD analysis. (Author)

A95-38078 Mechanical properties of friction welded joints of AZ31 magnesium alloy to 1050 aluminum. K. KATOH, T. ASAHINA, and H. TOKISUE (Nihon Univ., Narashino, Japan), *Japan Institute of Light Metals, Journal* (ISSN 0451-5994), Vol. 45, No. 5, 1995, pp. 255–260. In Japanese. 8 Refs. Documents available from Aeroplus Dispatch.

The mechanical properties of friction welded joints of AZ31 magnesium alloy to 1050 aluminum, which were made by a brake-type friction welding machine, were examined by mechanical tests and optical micrography. The burr on the welds occurs from 1050 aluminum, and it is enveloped in the AZ31 alloy at the weld zone regardless of the welding conditions. It is recognized that the original fibrous structures disappeared near the weld interface. Both the compound layer and the mechanical mixing layer were observed on the weld zone. The hardness of the weld interface has a higher value than that of the base metal. The tensile strength of the welded joints is improved by increasing the friction time. In the case of friction pressure at 70 MPa, the tensile strength of the welded joints is slightly higher than that of the 1050 aluminum, but friction welded joints under the friction pressures of 50 and 60 MPa are inferior to that of the 1050 aluminum. The elongation of all the welded joints are inferior to that of the AZ31 alloy. All the tensile specimens are fractured at the weld interface. The impact specimens in which a notch is put into the weld interface show an impact strength lower than that of the AZ31 alloy. (Author)

A95-37233 Effect of *n* value on formability of Al-Mg alloys. H. UCHIDA and H. YOSHIDA (Sumitomo Light Metal Industries, Ltd., Nagoya, Japan), *Japan Institute of Light Metals, Journal* (ISSN 0451-5994), Vol. 45, No. 4, 1995, pp. 193–197. In Japanese. 8 Refs. Documents available from Aeroplus Dispatch.

n value of Al-Mg alloys is not constant with strain, since it increases to a maximum and decreases. The changes of *n* value and microstructures during tensile deformation suggest as follows. When *n* value increases with strain, dislocation density increases. When *n* value is stable with strain, microstructures change little. When *n* value decreases with strain, the formation and growth of dislocation cell structures occur and cause to dynamic recovery. The stability of *n* value is more important than the maximum *n* value to obtain good formability. The alloys having stable *n* value with wider strain region are considered as materials with better formability. (Author)

A95-37232 Effect of alloying elements on plastic behaviour of magnesium alloys with the hcp structure. W. FUJITANI and Y. UMAKOSHI (Osaka Univ., Japan), *Japan Institute of Light Metals, Journal* (ISSN 0451-5994), Vol. 45, No. 4, 1995, pp. 181–186. In Japanese. 9 Refs. Documents available from Aeroplus Dispatch.

Plastic behavior of or-phase binary Mg alloys containing Al, In, Li, Sn, or Zr was investigated at temperatures between 77 and 573 K. Addition of In, Sn, Al, and Zr increased yield stress of these binary alloys, while Mg-4 pct Li alloy was softened by Li addition at room temperature. Mg-4 pct Al and Mg-4 pct Li alloys showed good ductility but no significant improvement in ductility was observed in other alloys. Activation of deformation twins which was observed by characterizing the acoustic emission signals during tensile test was responsible for good ductility of Mg-4 pct Al alloy, while addition of Li activated the non-basal slip resulting in improving ductility of Mg-4 pct Li alloy at room temperature. (Author)

A95-35691 High strength and high strain rate superplasticity in a Mg-Mg_2Si composite. M. MABUCHI (Nagoya, National Industrial Research Inst., Japan), K. KUBOTA (Mitsui Mining and Smelting Co., Ltd., Saitama, Japan), and K. HIGASHI (Osaka Prefecture, Univ., Sakai, Japan), *Scripta Metallurgica et Materialia* (ISSN 0956-716X), Vol. 33, No. 2, 1995, pp. 331–335. 13 Refs. Documents available from Aeroplus Dispatch.

A Mg-Mg_2Si composite was processes from rapidly solidified ribbons, and the mechanical properties of the composite were investigated by tensile tests. The composite exhibited high strength (about 500 MPa) at room temperature and superplastic behavior at high strain rates (about 0.1–1/s) at 773 K. The high strain superplasticity is attributed to the very small grain size of the material (about 1 μ).

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% 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.

A95-22597 Some characteristics of TIG welded joints of AZ31 magnesium alloy. T. ASAHINA and H. TOKISUE (Nihon Univ., Narashino, Japan), *Japan Institute of Light Metals, Journal* (ISSN 0451-5994), Vol. 45, No. 2, 1995, pp. 70–75. In Japanese. 11 Refs. Documents available from Aeroplus Dispatch.

AZ31 magnesium alloy plates 4 mm in thickness were welded without addition of filler wire using a pulsed AC TIG welding machine. Microstructural observations have been carried out together with the mechanical tests on the welded joints, with the special reference to the effects of pulse frequency on the optimum welding conditions. In case of a pulse frequency of 20 Hz, the crystal grains of the fusion zone are most fine. The hardness of the fusion zone of welded joints are nearly equal to that of the base metal. The welded joints without pulse have the same tensile strength and elongation as those of the base metal. The highest tensile strength and elongation of pulsed welded joints can be obtained with the pulse frequency of 20 Hz, but they are inferior to those of the base metal. All the welded joints are fractured at the center of the fusion zone regardless of the pulse frequency. The bending angle of welded joints is smaller than that of the base metal. Fatigue limit of the welded joints with the pulse frequency of 20 Hz is 92% of the base metal. The fatigue limit of the pulse welded joints depends on the grain size of the fusion zone. (Author)

A95-22596 SiC(p)/Mg-Ce and Mg-Ca alloy composites obtained by spray forming. A. NOGUCHI (Nippon Light Metal Co., Ltd., Osaka, Japan), I. EZAWA (Sumitomo Light Metal Industries Co., Ltd., Nagoya, Japan), J. KANEKO, and M. SUGAMATA (Nihon Univ., Narashino, Japan), *Japan Institute of Light Metals, Journal* (ISSN 0451-5994), Vol. 45, No. 2, 1995, pp. 64–69. In Japanese. 12 Refs. Documents available from Aeroplus Dispatch.

SiC particulate dispersed Mg-10 percent Ce and Mg-5 percent Ca alloy composites were successfully obtained by using an experimentally constructed spray forming apparatus with simultaneous injection of SiC particles. The spray formed composites showed relative density higher than 95%. The relative density was improved to above 99% by hot extrusion. The uniformity in distribution of dispersed SiC particles was also improved by hot extrusion. It has been shown that fine SiC particles which are even smaller than 1 μ in diameter can be dispersed by spray forming technique. The measured V(f) of SiC particles in spray formed and hot extruded materials increased with an increase of the average particle size. The obtained V(f) of coarse SiC particles which is 12 μ in average size was as high as 18.8%. The elastic modulus and hardness were appreciably increased by dispersion of SiC particles. However, improvement in tensile strength was not observed in the composites. (Author)

A95-20750 Manufacturing conditions and mechanical properties of alumina short fiber/AZ91D magnesium alloy composites. M. NAKAGAWA, T. WADA, S. KAMADO, and Y. KOJIMA (Nagaoka Univ. of Tech-

nology, Japan), *Japan Institute of Light Metals, Journal* (ISSN 0451-5994), Vol. 45, No. 1, 1995, pp. 21–26. In Japanese. 5 Refs. Documents available from Aeroplus Dispatch.

Alumina short fiber/AZ91D magnesium alloy composites are fabricated using a squeeze casting method. In this study, the effect of the graphite lubricant on the preform deformation was investigated. Additionally, macro- and microstructures and mechanical properties of the composites fabricated at the optimum condition are investigated. The preform deformation is caused by the alpha phase that crystallizes near the surface of a die. Namely, the primary alpha phase accumulates on the preform and disturbs the molten metal infiltration during squeeze casting. As the result, high compressive pressure acts on the preforms and causes the preform deformation. The coefficient of heat transfer becomes a small value by coating the graphite lubricant on the inside of a die. In this case, no alpha phase crystallizes near the surface of a die before squeeze casting. Therefore, the preform deformation does not occur. T6 treatment improves tensile strength of the composites at room temperature. (Author)

A95-20749 Microstructural changes of strained AZ91D magnesium alloys on semi-solid state. S. MATSUI (Japan Steel Works, Ltd., Muroran), K. SEKIHARA, S. KAMADO, and Y. KOJIMA (Nagaoka Univ. of Technology, Japan), *Japan Institute of Light Metals, Journal* (ISSN 0451-5994), Vol. 45, No. 1, 1995, pp. 15–20. In Japanese. 8 Refs. Documents available from Aeroplus Dispatch.

Reheating and isothermal holding was carried out using strained AZ91D magnesium alloy bulks, briquets, and chips to get fine solid particles. Furthermore, semisolid stirring was conducted employing chips, with fine solid particles during isothermal holding. Magnesium solid solution (alpha-phase) in each raw material recrystallizes on reheating; melting then occurs at the interface between alpha-phase and eutectic compound, and recrystallized grain boundary below the holding temperature. At isothermal holding temperature, solid particles break up nearly perfectly and are finer spherical particles than those of commercial bulk sample. The spherical solid particles coarsen in proportion to the cube root of the holding time. From analyses of the distribution of solid particle diameters, it is clear that the contribution of coalescence to the particle growth decreases and that of Ostwald ripening increases with the lapse of time.

A95-17875 New class of amorphous and icosahedral phases in Zn-Mg-rare-earth metal alloys. A. NIIKURA, A.-P. TSAI, A. INOUE, and T. MASUMOTO (Tohoku Univ., Sendai, Japan), *Japanese Journal of Applied Physics, Part 2* (ISSN 0021-4922), Vol. 33, No. 11A, 1994, pp. L1538–L1541. 22 Refs. Documents available from Aeroplus Dispatch.

A new class of amorphous and icosahedral phases was obtained in rapidly solidified Zn-Mg-rare-Earth metal (RE) ternary alloys. The rapidly solidified alloy structure exhibits the amorphous phase when it contains the RE elements of La, Ce, Pr, or Eu with large atomic size. On the other hand, it exhibits the icosahedral phase when it contains Nd, Sm, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, or Y. The tendency for the formation of amorphous or icosahedral phase is mainly dominated by the atomic size of RE elements. (Author)

A95-15425 Friction welding of cast-to-wrought magnesium alloy. K. KATOH, T. ASAHINA, and H. TOKISUE (Nihon Univ., Narashino, Japan), *Japan Institute of Light Metals, Journal* (ISSN 0451-5994), Vol. 44, No. 10, 1994, pp. 562–566. In Japanese. 8 Refs. Documents available from Aeroplus Dispatch.

Wrought magnesium alloy AZ31 was friction welded to magnesium alloy castings AZ91 using a brake type friction welding machine. Microstructure and mechanical properties of friction welded joint were investigated. Microstructures of the first weld zone are quite similar to those of the second weld zone. A fine grain structure is observed on the side of alloy AZ91 near the weld interface, while on the heat-affected zone of alloy AZ31, a modified fiber structure is observed along the flow direction of burr. The hardness at the weld interface is higher than that of the base metals. In the case of alloy AZ91, the hardness in heat-affected zone is higher than that in the base metal, and in the case of alloy AZ31, it is nearly equal to that of the base metal. The tensile strength of joints welded at a friction pressure between 50 and 60 MPa is 90–106% of the castings. However the elongation of welded joints is inferior to that of alloy AZ91. (Author)

A95-15423 Influence of grain size and Mg content on the ductility of Al-Mg alloys at low temperatures. M. YNAGAWA (Kobe Steel, Ltd., Japan), *Japan Institute of Light Metals, Journal* (ISSN 0451-5994), Vol. 44, No. 9, 1994, pp. 492–497. In Japanese. 14 Refs. Documents available from Aeroplus Dispatch.

Influence of grain size and Mg content on the ductility of Al-Mg alloys at 77, 173, and 300 K has been investigated. As the grain size increased from 20 to 300 μ, the uniform elongation at 77 and 173 K reached maxima when grain size was 40 μ. On the other hand, at 300 K, the uniform elongation increased monotonously with increasing grain size. The local elongation at 300 K was nearly constant regardless of grain size and Mg content, while at 77 and 173 K the local elongation increased with decreasing grain size or Mg content and exceeded 10% at 77 K when grain size was 20 μ. Fractographic observations revealed that the area fraction of intergranular fracture at 77 K increased with increasing grain size or Mg content. On the other hand, intergranular fracture was not observed at 177 and 300 K regardless of grain size and Mg content. The dependence of elongation upon grain size and Mg content at 77 K was explained mainly by the intergranular fracture. (Author)

A95-11513 Cast stuctures and grain refinement of superheat-treated Mg-Al alloy. T. MOTEGI, E. SATO (Chiba Inst. of Technology, Japan), and K. OBATA (NTT Corp., Tokyo, Japan), *Japan Institute of Light Metals, Journal* (ISSN 0451-5994), Vol. 44, No. 8, 1994, pp. 427–432. In Japanese. 9 Refs. Documents available from Aeroplus Dispatch.

To investigate the mechanism of grain refinement of a superheat-treated Mg alloy, pure magnesium samples containing 0–10 at.% Al were heated at 900 C and held for 1800 s. The samples were then cooled at a constant rate and cast into a metallic mold at 660 or 680 C. Samples were melted in the graphite, cast iron, and magnesia crucibles to examine the effect of impurity elements in the crucible on the grain size. Metallographic examinations were performed to measure the grain size of solidified structures. An electron probe microanalyzer was used to find the foreign particles for heterogeneous nucleation in the fine grains. The grain refinement of superheat-treated Mg-Al alloys depends on aluminum content. The finest grain size was obtained in the Mg-6 at.% Al alloy. The grain size became coarser as the aluminum content increased or decreased from 6%. The molten magnesium alloy attacked the iron and magnesia crucibles, so that Fe and Si contents of samples increased. (Author)

N94-28164 The corrosion behavior of sputter-deposited magnesium-valve metal alloys. E. HIROTA, H. HABAZAKI, A. KAWASHIMA, K. ASAMI, and K. HASHIMOTO, In its The Science Reports of the Research Institutes, Tohoku University. Series A: Physics, Chemistry, and Metallurgy. Volume 38, No. 1: Amorphous Materials 14, pp. 53–62 (SEE N94-28158 07-26). Documents available from Aeroplus Dispatch.

An attempt was made for preparation of magnesium alloys with valve metals, such as titanium, zirconium, niobium, and tantalum whose melting point far exceed the boiling point of magnesium. These alloys became single phase solid solutions in wide composition ranges but were crystalline in contrast to the fact that other alloys with valve metals such as nickel-, copper-, and aluminum-base alloys were amorphous in wide composition ranges. The alloys containing sufficient amounts of valve metals showed high corrosion resistance due to spontaneous passivation in 1 M HCl at 30 C. The high corrosion resistance was attributed to the formation of passive oxyhydroxide films in which valve metal cations were remarkably concentrated. However, because of crystalline alloys and because of the presence of active magnesium, their corrosion resistance is lower than that of valve metals. (Author)

N94-26071 Formation of three types of quasi-crystals in Al-Pd-Mg system. N. KOSHIKAWA, K. EDAGAWA, Y. HONDA, and S. TAKEUCHI. Documents available from Aeoroplus Dispatch.

In the Al-Pd-Mg system, a Mackay-Icosahedron (MI) type Icosahedral (I) phase with the F-type superlattice order and a Decagonal (D) phase were found to form in a melt-quenched state, in addition to the Frank-Kasper (FK) type stable I-phase reported previously. This is the first example in which the three types of quasi-crystalline phases are formed in the same alloy system. The formation range of the FK-type I-phase in melt-quenched state is rather wide: 5–20 at percent Pd and 20–45 at percent Mg. In contrast, the MI-type, I-phase and D-phase are formed in small composition ranges around Al52Pd31Mg17 and Al74Pd21Mg5, respectively. Electron diffraction studies showed that the period along the tenfold axis of the D-phase is about 1.6 nm. The formation and stability of the MI-type and FK-type I-phases were discussed in terms of a Hume-Rothery rule. (Author)

A94-15565 Tensile properties and stress corrosion cracking resistance of extruded high strength Al-8Zn-1Mg system alloys. Y. KISHI, Y. HIROSE (Kanazawa Univ., Kakuma, Japan), I. TSUKUDA, S. NAGAI (Showa Aluminum Co., Sakai, Japan), and K. HIGASHI (Osaka Prefecture, Univ., Sakai, Japan), *Japan Society of Materials Science, Journal* (ISSN 0514-5163), Vol. 42, No. 479, 1993, pp. 990–996. In Japanese. 14 Refs. Documents available from Aeroplus Dispatch.

An investigation is conducted of the resistance of an Al-Zn-Mg alloy with various additions of Cu and La to stress corrosion cracking, as well as these additions' effect on tensile strength. The reduction of grain size with Cu and La additions improved tensile properties; the La-bearing alloy also exhibited high resistance to stress corrosion cracking.

A94-10365 Determination of constitutive equation of superplastic deformation by incorporation of temperature dependence of grain size. K. HIGASHI, Y. MATSUMURA, and S. TANIMURA, *Japan Society of Mechanical Engineers, Transactions A* (ISSN 0387-5008), Vol. 59, No. 563, 1993, pp. 1669–1675. In Japanese. 3 Refs. Documents available from Aeroplus Dispatch.

To determine the controlling mechanism during superplastic deformation, the activation energy for superplastic flow associated with the diffusion flow process was measured for two powder metallurgically processed Al-Mg-Mn alloys. The apparent activation energies between 181 and 190 kJ/mol for superplastic flow measured in Al-Mg-Mn alloys were higher than that for self-diffusion of aluminum (142 kJ/mol). The activation energies for superplastic flow measured in both alloys were found to be similar to grain boundary diffusion (84 kJ/mol) by incorporation of the temperature dependence of threshold stress and shear modulus into the constitutive equation, whereas, by additional incorporation of the temperature dependence of grain size, the true activation energies were equal to that of lattice self-diffusion of aluminum base metal, and all data in both alloys can be represented by a single equation. It is inferred that a single mechanism exists in both alloys. The rate-controlling step in the deformation process is argued to be controlled by diffusional-flow-related phenomena within the grains during the superplastic flow.