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(54) **CASE MADE OF MAGNESIUM ALLOY**

(57) The present invention provides a high-quality magnesium alloy case having a complex shape in which formability is ensured by specifying the composition of the magnesium alloy and setting the amount of internal impurities to an appropriate value or below, and the present invention is a magnesium alloy case comprising a superplastica body formed by the superplastic forming of a magnesium alloy sheet material, which is containing 1.0 to 10.0 mass% of aluminum, 0.5 to 3.0 mass% of zinc, and 0.1 to 0.8 mass% of manganese as a part of added alloy elements and has an oxygen concentration of 300 mass ppm or less, and the case having a structure being inhibited in cavity formation during the superplastic forming, and in accordance with the present invention, it is possible to manufacture and provide a magnesium alloy case having a complex shape through superplastic forming by accurately regulating the composition and impurities content of the magnesium alloy sheet material. The magnesium alloy case in accordance with the present invention can be actively applied, for example, to cases of household electronic products.

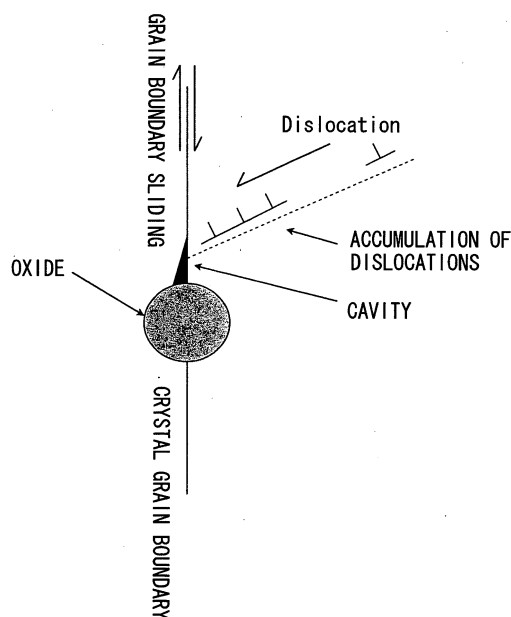


Fig. 4

DescriptionTECHNICAL FIELD

[0001] The present invention relates to a magnesium alloy case comprising a superplastically formed body of a magnesium alloy sheet or plate material, and more particularly to a high-quality magnesium alloy case having a complex shape, which comprises a superplastically formed body and in which the formation of cavities during the superplastic forming is inhibited by highly accurately controlling the material composition and oxygen concentration in the magnesium alloy sheet material, and also to a technology for manufacturing the magnesium alloy case. The present invention provides a novel magnesium alloy case which has such properties as high resistance to fracture and a high strength and which can be used in a wide variety of fields including aerospace material, materials for electronic devices, automobile parts and the like.

BACKGROUND ART

[0002] Magnesium alloy materials have the lowest density ($= 1.7 \text{ g/cm}^3$) among the practical structural metallic materials, and the magnesium alloy materials have attracted attention as next-generation lightweight structural materials because they have good recyclability inherent to metal materials and because natural resources therefor are abundant. Presently, most magnesium products in Japan are fabricated by a casting process such as die casting and thixocasting. The possibility of forming thin products by such methods is the main reason for successful industrial utilization of magnesium alloy materials. In particular, in household electronic products, cast magnesium alloy materials have been used for cases, for example, cases of personal computers, cellular phones, and digital cameras. However, the problems associated with the industrial manufacture of magnesium alloy materials by the existing casting methods include the necessity of conducting the after-treatment to repair the casting defects, a low yield, and problematic strength and rigidity of the products.

[0003] Plastic processing can be considered as an effective method and the demand therefor is growing because it has a high yield and provides for increased strength and toughness simultaneously with forming. In particular, the possibility of fabricating formed bodies from magnesium alloy sheet materials by a deep drawing, stretch forming, and blow forming would enable the manufacture of thin-wall and high-strength formed bodies by an inexpensive process, and strong demand, e.g., for cases of household electronic products manufactured by such a process can be expected. However, there are only very few examples of magnesium alloy members fabricated by plastic processing.

[0004] A critical decomposition shear stress of non-base sliding of a magnesium alloy is much larger than that of other sliding systems at normal temperature, and the formability of the magnesium alloy at normal temperature is low. Furthermore, a specific feature of rolled magnesium alloy materials is that a texture in which a {0001} plane is oriented parallel to the sheet surface is formed therein and strains in the sheet thickness direction during plastic deformation cannot be expected, this being a factor inhibiting formability of the magnesium alloy at normal temperature. Because of the above-described problems, it is essentially difficult to implement cold press forming, which is a major reason why magnesium alloy members cannot be fabricated by plastic processing.

[0005] A forming method that uses superplastic deformation has attracted attention as a method for forming magnesium alloys, which have poor cold formability, by plastic processing. A superplastic phenomenon is developed in metal materials when crystal grains are refined. In accordance with the present invention, superplastic deformation is understood as "a phenomenon in which a deformation stress demonstrates strong dependence on a strain rate in tensile deformation of a polycrystalline material, and a gigantic elongation in excess of several hundreds of percents is demonstrated without causing local shrinkage". In such a superplastic deformation, the shape of the crystal itself is basically not changed and deformation is attained by sliding at the crystallite interfaces. This phenomenon is called as grain boundary sliding. Superplastic deformation generally occurs when crystal grain diameter of a material is decreased and a sample is heated to a temperature of about 50% the liquidus temperature or to a higher temperature.

[0006] Examples relating to methods for forming magnesium alloy sheet materials by using superplastic forming include: (1) a magnesium alloy part and a method for manufacture thereof (Japanese Patent Application Laid-open No. 2004-149841), (2) a magnesium alloy part and a method for manufacture thereof (Japanese Patent Application Laid-open No. 2003-311360), (3) a method for spindle processing of a magnesium material and an apparatus therefor (Japanese Patent Application Laid-open No. 2000-126827), and (4) a method for deep drawing of a magnesium alloy sheet material and a formed body obtained (Japanese Patent Application Laid-open No. 2004-58111). An important feature of these methods is that a complex structural member can be fabricated by superplastic forming by performing boss formation, spindle processing, and deep drawing with respect to a sheet material.

DISCLOSURE OF THE INVENTION

[0007] Grain boundary sliding is the main superplastic deformation mechanism of magnesium alloys. A principle diagram of grain boundary sliding is shown in FIG. 1. Grain boundary sliding indicates a mechanism by which deformation is attained by crystals moving along grain boundaries, without intragranular deformation. When ideal grain boundary sliding occurs between crystals, the crystals move along grain boundaries, without intragranular deformation. Therefore, a cavity unavoidably appears in the vicinity of a triple point of the grain boundary. FIG. 2 shows a temperature dependence of grain boundary diffusion coefficients of various alloys (M. Mabuchi et al.: "Tensile Properties at Room Temperature to 823 K of Mg-4Y-3RE Alloy", Mater. Trans. 43 (2002), pp. 2063-2068). In FIG. 2, a dimensionless temperature normalized by melting point is plotted against the abscissa. A dimensionless grain boundary diffusion coefficient is plotted against the ordinate. A grain boundary diffusion coefficient of magnesium can be confirmed to be much higher than that of aluminum and iron over the entire temperature range. Even if a cavity appears in the vicinity of a triple point of grain boundaries during superplastic deformation in magnesium, which has a high grain boundary diffusion coefficient, the formation of cavities apparently can be moderated by diffusion. This is why superplastic forming can be actively used as a method for forming magnesium alloys.

[0008] On the other hand, when a commercial magnesium alloy sheet material is subjected to superplastic forming, an error in the forming conditions causes the formation of cavities and the material is ruptured during forming. FIG. 3 shows the pattern of internal cavities occurring when a rolled material of an AZ31 magnesium alloy (Mg - 3 mass% Al - 1 mass% Zn - 0.5 mass% Mn) is subjected to tensile deformation at a temperature of 623 K and a strain rate of $1 \times 10^{-3} \text{ sec}^{-1}$ to a true strain of 0.9. Further, in this case, the initial grain diameter was 10 μm . According to FIG. 3, the presence of fine cavities with a size of less than 1 μm and comparatively coarse cavities with a size of 5 μm or more can be confirmed. The cavities observed in FIG. 3 occur when the formation of cavities in the vicinity of grain boundaries cannot be moderated by the diffusion of material. Thus, control of deformation temperature that affects the diffusion rate and control of strain rate that affects the cavity formation rate are extremely important elements in superplastic forming.

[0009] Not only the grain boundaries, but also internal impurities can be considered as origination points for the formation of cavities during superplastic deformation. However, as an alloy specifications, magnesium alloys have no standards on impurities that originate in formability, and no measures designed to eliminate the effect of impurities on superplastic deformation can be found therein. The present invention has been created with the foregoing in view based on the discovery made by the inventors that a process of fabricating and providing a magnesium alloy case which is ensuring formability as a superplastically formed body and having a complex shape can be realized by specifying the composition of the magnesium alloy sheet material and reducing the amount of internal impurities to an appropriate value or below. It is an object of the present invention to provide a high-quality magnesium alloy case that has a complex shape and ensures formability as a superplastically formed body.

[0010] The present invention that resolves the above-described problems and provides a magnesium alloy case comprising a superplastically formed body of a magnesium alloy sheet material that comprises 1.0 to 10.0 mass% of aluminum, 0.5 to 3.0 mass% of zinc, and 0.1 to 0.8 mass% of manganese as a part of added alloying elements and has an oxygen concentration of 300 mass ppm or less, this superplastically formed body having a structure in which the formation of cavities during the superplastic forming is inhibited. The preferred aspects of the magnesium alloy case are as follows: (1) the case comprises a superplastically formed body of a magnesium alloy sheet material with an oxygen concentration of 100 mass ppm or less, (2) some zones of the magnesium alloy sheet material are formed by the superplastic forming, (3) the superplastic forming is a deep drawing, (4) the superplastic forming is a stretch forming, (5) the superplastic forming is a blow forming, and (6) crystal grains in part of the magnesium alloy case have a size of 20 μm or less. The present invention also relates to a structural lightweight member comprising the magnesium alloy case.

[0011] The present invention will be described below in greater detail.

[0012] The inventors have focused their attention on oxides present inside a magnesium alloy sheet material as means for ensuring formability as a superplastically formed body and making it possible to provide a high-quality magnesium alloy case having a complex shape. From amongst practical metals, magnesium has the highest affinity to oxygen and it has been used as a deoxidizing agent in iron and steel refining and the like. In the alloy preparation and casting of magnesium alloys, the operations are performed under a cover gas such as a gas mixture of SF_6 and CO_2 so that molten magnesium does not come into contact with the air, but due to process restrictions it is difficult to avoid oxidation of molten magnesium occurring before the solidification stage. Oxides (MgO or Al_2O_3) that are nonmetallic inclusions are presently separated by aggregation, flotation and precipitation induced by blowing argon into magnesium in a molten state.

[0013] When the oxides are admixed in excess to a magnesium alloy sheet material that will be subjected to superplastic forming, the cavity formation starts from the oxides. A mechanism of cavity formation is shown in FIG. 4. Because stress concentration occurs close to the oxides during superplastic forming and also because dislocations are accumulated around the oxides, cavity formation that starts from oxides is initiated. When cavity formation shown in FIG. 4 occurs frequently in a material, the cavities are associated together, thereby causing fracture. Based on the results of comprehensive research and development, the inventors have gained new insights, namely, that superplastic deformation can

be achieved, while inhibiting the formation of cavities, and a high-quality case made of a magnesium alloy sheet material and having a complex shape can be created by controlling the concentration of oxygen in the material to an appropriate value and further adding appropriately additional elements to magnesium.

[0014] More specifically, it was experimentally confirmed that a magnesium alloy can be provided with a complex shape by using superplastic forming by controlling the concentration of oxygen in a magnesium alloy sheet material to 300 mass ppm or less, preferably 100 mass ppm or less. Thus, it was found that by controlling the oxides present inside a magnesium alloy sheet material to a predetermined amount, even if cavity formation starts from the oxides during superplastic forming, the cavities do not expand and are moderated by diffusion. On the other hand, the increase in the concentration of oxygen in the magnesium alloy sheet material raises the probability of the oxides being present as impurities in the grain boundary triple points. When oxides are present in the grain boundary triple points, the oxides become barriers for grain boundary diffusion and inhibit the moderation of cavity formation, thereby greatly degrading the formability. For this reason, the oxides should be prevented as thoroughly as possible from being incorporated into the magnesium alloy sheet material. Thus, the inventors have confirmed that a phenomenon according to which the oxides enhance the formation of cavities can be inhibited by suppressing the concentration of oxygen to 300 ppm or less, preferably to 100 ppm. If the concentration of oxygen in the magnesium alloy sheet material exceeds 300 ppm, the aforementioned cavity formation and expansion of cavities cannot be inhibited. In accordance with the present invention, it is especially important that the superplastically formed body be manufactured by using a magnesium alloy sheet material in which the concentration of oxygen is highly accurately controlled to a predetermined range so that the concentration of oxygen does not exceed 300 mass ppm.

[0015] In accordance with the present invention, where a magnesium alloy has fine crystal grains of 20 μm or less, preferably fine crystal grains of 15 μm or less, the superplastic phenomenon can be easily demonstrated in a temperature range of 473 K or higher to 723 K or lower and strain rate region of 1×10^{-5} 1/sec or more to 1×10^{-1} 1/sec or less. Here, a process in which a strain in part of a magnesium alloy sheet material is 1.0 or more or part of the sheet material is deformed by grain boundary sliding is defined as superplastic deformation. When a sheet material is deformed by grain boundary sliding, crystal grains of the sheet material do not grow during forming or the crystal grains are refined following the dynamic recrystallization. Thus, in accordance with the present invention, when the crystal grains in the zone of the formed body where the largest deformation has occurred are 20 μm or less, preferably 15 μm , it can serve as evidence of superplastic forming.

[0016] Theoretically, it is necessary that the crystal grain diameter of a magnesium alloy sheet material supplied to superplastic forming be decreased to 20 μm or less. On the other hand, a magnesium alloy sheet material having comparatively coarse grains with a diameter of about 40 μm also can be supplied to superplastic forming. Even when a magnesium alloy sheet material having coarse grains of about 40 μm in diameter is supplied to superplastic forming, the crystal grains of the sheet material can be refined and effective superplastic forming can be provided to the magnesium alloy sheet material by using dynamic recrystallization that accompanies the processing.

[0017] In order to inhibit the growth of crystal grains during forming and also to ensure strength and corrosion characteristics of the magnesium alloy sheet material after forming, it is necessary to regulate accurately other components of the magnesium alloy. More specifically, it is preferred that the alloy comprise 1.0 to 10.0 mass% of aluminum, 0.5 to 3.0 mass% of zinc, and 0.1 to 0.8 mass% of manganese as a part of added alloy elements.

[0018] Thus, in accordance with the present invention, it is preferred that 1.0 to 10.0 mass% of aluminum be added as an additional alloying element. By adding 1 mass% or more of aluminum, solid solution strengthening of the magnesium alloy can be expected. If 6 mass% or more of aluminum is added, then a network-like β phase ($\text{Mg}_{17}\text{Al}_{12}$) can precipitate on grain boundaries, thereby further increasing the strength of the material. On the other hand, if 10 mass% or more of aluminum is added, then ductility of the magnesium alloy after forming might be greatly degraded. Therefore, it is preferred that the amount of aluminum added to the alloy is 1.0 mass% or more to 10 mass% or less.

[0019] Further, in accordance with the present invention, the addition of zinc is necessary to maintain the strength of recycled material. On the other hand, the addition of 3.0 mass% or more of zinc sometimes causes undesirable degradation of corrosion characteristic. Manganese can moderate the influence of iron that is an impurity element degrading corrosion resistance, and this effect is demonstrated most effectively when manganese is added within the above-described range.

[0020] Further, in accordance with the present invention, the addition of manganese is indispensable for controlling the crystal grain size of the magnesium alloy sheet material. Thus, crystal grains inside the material grow during superplastic forming and fine crystal grains that can initiate grain boundary sliding are difficult to maintain unless an appropriate amount of manganese is added. More specifically, it is preferred that 0.1 mass% or more of manganese be added. On the other hand, if 0.8 mass% or more of manganese is added, then coarse intermetallic compounds of manganese and aluminum are formed inside the material and an adverse effect is produced on ductility and strength of the material. Accordingly, the addition of 0.8 mass% or more of manganese is undesirable.

[0021] The magnesium alloy case in accordance with the present invention that is obtained by subjecting the magnesium alloy sheet material to a superplastic forming does not depend on the type of the superplastic forming. Examples

of processes suitable for forming the magnesium alloy sheet material by the superplastic forming include a deep drawing, stretch forming, and blow forming. In accordance with the present invention, formability as a superplastically formed body can be ensured and a high-quality case having a complex shape can be manufactured essentially by highly accurately controlling the material quality of the magnesium alloy sheet material, and a magnesium alloy case manufactured by using any method can be the object of the present invention.

[0022] Where specific amounts of aluminum, zinc, and manganese are added as part of additional elements to a magnesium alloy sheet material in order to manufacture the magnesium alloy case in accordance with the present invention through superplastic forming, fine crystal grains can be maintained by the superplastic forming. More specifically, by highly accurately controlling the amount of these additional elements and the concentration of oxygen, it is possible to manufacture a magnesium alloy case comprising a superplastically formed body in which crystal grains in part of the magnesium alloy case have a size of 20 μm or less. The yield strength (hardness) of a magnesium alloy has strong correlation with a crystal grain size, and the manufacture of a high-strength case can be realized by refining the crystal grains to 20 μm or less. With the conventional technology, the formation of cavities in superplastic forming was difficult to prevent and the crystal grains were difficult to refine to a size of 20 μm or less, but in the magnesium alloy case manufactured in accordance with the present invention, the formation of cavities caused by superplastic forming is inhibited to a degree larger than that in the case manufactured through other processes, the crystal grains are refined to a size of 20 μm or less, and a product with high fracture resistance and high strength is therefore obtained. By analyzing these properties, the two products can be clearly distinguished (identified).

[0023] The present invention demonstrates the following noticeable effects: (1) a magnesium alloy case having a complex shape can be manufactured by a superplastic forming by controlling the material composition and oxygen concentration of a magnesium alloy sheet material; (2) a magnesium alloy case comprising a superplastically formed body having a high fracture resistance and a high strength and having a structure in which the cavities to be formed during the superplastic forming is inhibited can thereby be provided; (3) an ultra-lightweight magnesium alloy case that is expected to serve as a next-generation structural lightweight material can be provided.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024]

FIG. 1 shows a principle of grain boundary sliding. This figure shows how a material is deformed when crystals move along grain boundaries, without causing deformation inside the crystal grains.

FIG. 2 shows a temperature dependence of grain boundary diffusion coefficients of magnesium, iron, and aluminum. The grain boundary diffusion coefficient of magnesium is shown to be much higher than those of aluminum and iron over the entire temperature range. A dimensionless temperature normalized by a melting point is plotted against the abscissa, and a normalized grain boundary diffusion coefficient is plotted against the ordinate.

FIG. 3 shows the pattern of internal cavities occurring when a rolled material of an AZ31 magnesium alloy (Mg - 3 mass% Al - 1 mass% Zn - 0.5 mass% Mn) is subjected to tensile deformation at a temperature of 623 K and a strain rate of $1 \times 10^{-3} \text{ sec}^{-1}$ to a true strain of 0.9. This figure shows the formation of fine cavities with a size of less than 1 μm and comparatively coarse cavities with a size of 5 μm or more. The initial crystal grain size is 10 μm .

FIG. 4 illustrates the principle of cavity formation during superplastic forming when impurities are present inside the material. Because stress concentration occurs in the vicinity of oxides during superplastic forming and also because dislocations are accumulated around the oxides, cavity formation that starts from oxides is initiated.

FIG. 5 shows the shape of a die used for blow forming in the embodiments.

FIG. 6 shows the external appearance of the magnesium alloy sheet material after blow forming as viewed from a side surface. The results are obtained when the applied gas pressure is 0.5 MPa and 0.2 MPa. The results indicate that formability of the sheet material is degraded with the increase in internal oxygen concentration of the magnesium alloy sheet materials.

FIG. 7 shows sheet thickness strain distribution of the sample subjected to blow forming in Embodiment (Example) 3 and Embodiment (Example) 11. The figure shows that a sheet thickness strain of 1.0 or more is demonstrated in some zones of the sample. The X axis shows the measurement zones of strains and shows a sheet thickness strain distribution on concentric circles, wherein the central portion of the sheet material is assumed to be at 0 mm. The Y axis shows the sheet thickness strain distribution in various measurement points.

BEST MODE FOR CARRYING OUT THE INVENTION

[0025] The present invention will be described below in greater detail based on embodiments (working examples) thereof. However, the present invention is not limited to these embodiments.

[0026] Rolled materials of an AZ31 magnesium alloy having different oxygen concentrations were prepared and

superplastic formability thereof was evaluated. The AZ31 magnesium alloy has a composition of Mg - 3 mass% Al - 1 mass% Zn - 0.5 mass% Mn and is a typical magnesium alloy to be used for wrought material. AZ31 magnesium alloy sheet materials with a width of 50 mm and a thickness of 5 mm that had different internal oxygen concentrations were prepared. These magnesium alloy sheet materials were subjected to hot rolling at a sample temperature of 673 K to manufacture rolled materials of magnesium alloys with a thickness of 1 mm. No roll heating was performed during hot rolling, and the draft ratio per 1 pass was 12%. The concentration of oxygen in the samples obtained and the average crystal grain size of the samples are presented together in Table 1. The concentration of oxygen was measured with a glow discharge mass spectrometer (GDMS), and the crystal grain size was measured by a section method by observing the structure of the plane parallel to the rolling direction under an optical microscope.

[Table 1]

Material	Oxygen concentration (mass ppm)	Grain size prior to forming (μm)
Sample 1	14	14.8
Sample 2	15	17.8
Sample 3	52	16.8
Sample 4	73	19.5
Sample 5	173	16.3
Sample 6	248	14.6
Sample 7	350	14.9
Sample 8	500	14.6

[0027] A rectangular magnesium alloy sheet material with a length of 70 mm, a width of 70 mm, and a thickness of 1 mm was cut out from the rolled material and subjected to superplastic blow forming. In the blow forming, a pressure die and a forming die shown in FIG. 5 were used. The magnesium alloy sheet material was fixed between two dies, the dies and the sample piece were heated to 673 K, and blow forming was implemented by blowing N_2 gas under a pressure of 0.2 MPa or 0.5 MPa on the magnesium alloy sheet material from the pressure die. The strain rate of the material under an applied pressure of 0.2 MPa is equivalent to about $1 \times 10^{-5} \text{ sec}^{-1}$, and the strain rate of the material under an applied pressure of 0.5 MPa is equivalent to about $1 \times 10^{-4} \text{ sec}^{-1}$. The forming was completed when part of the sheet material was ruptured.

[0028] The results obtained in blow forming the AZ31 magnesium alloy sheet materials of various types are shown in Table 2. A typical outer shape of the sheet material after blow forming is shown in FIG. 6. Observations of the outer shapes obtained in Embodiment (Example) 1 and Embodiment 7 shown in FIG. 6 confirm that a perfect cup shape could be formed in Embodiment 1. On the other hand, in Embodiment 7, although the cup shape could not be formed, a dome-like shape could be formed. The results obtained in Embodiment 1 and Embodiment 7 relate to a sheet material with the lowest internal oxygen concentration (14 mass ppm). According to the embodiments, the formability tended to degraded with the increase in oxygen concentration. The reference symbols shown in the "Formability" column of Table 2 represent the results obtained by visually comparing the results of the respective embodiments with the result obtained in Embodiment 1 or Embodiment 7. Thus, symbol $\circ$ indicates conditions under which practically no difference could be visually observed. Symbol Δ indicates conditions under which the formability was visually found to degrade locally. Symbol $\times$ indicates conditions under which degradation of formability was clearly confirmed by multiple forming under the same conditions. As shown in Embodiment 3 and Embodiment 11, in portions with $\circ$ and Δ , the formability could not be visually confirmed to degrade. On the other hand, as shown in Embodiment 7 and Embodiment 15, obvious degradation of formability was confirmed when the concentration of oxygen was more than 300 mass ppm.

[0029] Table 2 also shows the crystal grain size of samples after blow forming. The measurement location was a central portion of the sheet material that is the portion with the highest level of deformation of the sheet material. The table demonstrates that a state with fine crystal grains ($20 \mu\text{m}$ or less) was maintained in all the samples and the samples were deformed by superplastic forming.

[Table 2]

	Material	Pressure (MPa)	Oxygen concentration (mass ppm)	Grain size prior to forming (μm)	Formability	Grain size after forming (μm)
Embodiment 1	Sample 1	0.2	14	14.2	O	14.8
Embodiment 2	Sample 2	0.2	15	17.9	O	17.8
Embodiment 3	Sample 3	0.2	52	17.6	O	16.8
Embodiment 4	Sample 4	0.2	73	18.2	O	19.5
Embodiment 5	Sample 5	0.2	173	15.3	Δ	16.3
Embodiment 6	Sample 6	0.2	248	14.3	Δ	14.6
Embodiment 7	Sample 7	0.2	350	14.6	×	14.9
Embodiment 8	Sample 8	0.2	500	14.3	×	14.6
Embodiment 9	Sample 1	0.5	14	14.2	O	14.3
Embodiment 10	Sample 2	0.5	15	17.9	O	18.2
Embodiment 11	Sample 3	0.5	52	17.6	O	18
Embodiment 12	Sample 4	0.5	73	18.2	O	18.8
Embodiment 13	Sample 5	0.5	173	15.3	Δ	16.4
Embodiment 14	Sample 6	0.5	248	14.3	Δ	14.6
Embodiment 15	Sample 7	0.5	350	14.6	×	14.9
Embodiment 16	Sample 8	0.5	500	14.3	×	15.1

[0030] FIG. 7 shows the results obtained in observing cross sections of the samples subjected to blow forming in Embodiment 3 and Embodiment 11 and measuring the sheet thickness strains in various zones. The X axis shows the measurement zones of strains and shows a sheet thickness strain distribution on concentric circles, wherein the central portion of the sheet material is assumed to be at 0 mm. The Y axis shows the sheet thickness strain distribution in various measurement points. According to FIG. 7, a sheet thickness strain of 1.0 or more was confirmed in some measurement locations at any strain rate, thereby indicating that superplastic forming has been reached. Thus, it was confirmed that superplastic forming was developed in samples with highly accurately controlled oxygen concentration.

INDUSTRIAL APPLICABILITY

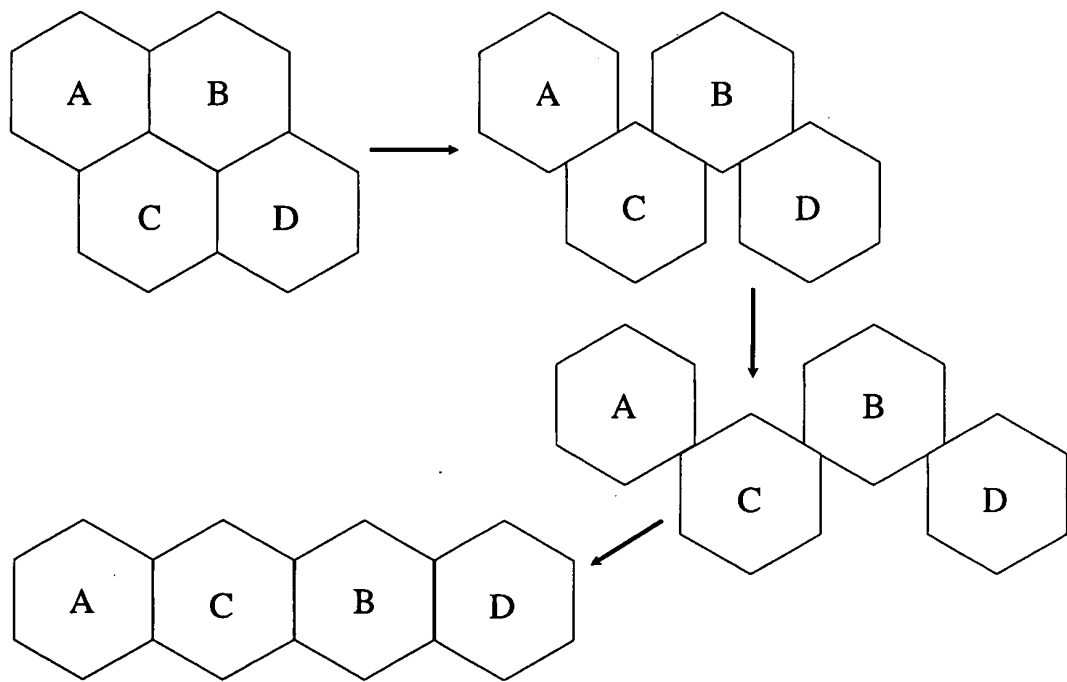
[0031] As described hereinabove, the present invention relates to a magnesium alloy case, and the invention can provide a magnesium alloy case having a complex shape, high fracture resistance and a high strength, and a structure in which cavity formation is inhibited even in superplastic forming by accurately specifying the composition and impurities of the magnesium alloy sheet material. The present invention is useful because it enables mass production and practical use of ultra-lightweight magnesium alloy cases that can be actively applied to cases of household electronic products, for example, digital cameras, notebook personal computers, and PDA.

Claims

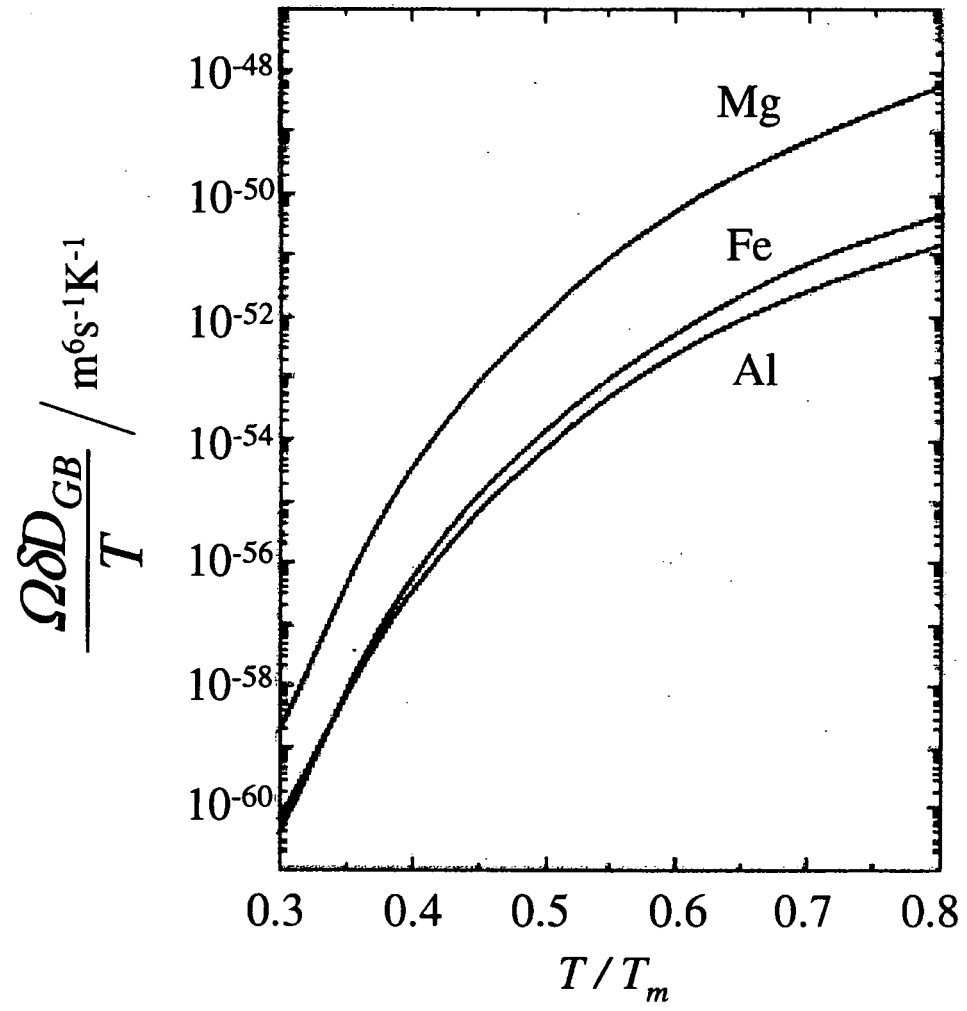
1. A magnesium alloy case **characterized by** comprising a superplastic body formed through the superplastic forming of a magnesium alloy sheet material, which is containing 1.0 to 10.0 mass% of aluminum, 0.5 to 3.0 mass% of zinc,

and 0.1 to 0.8 mass% of manganese as a part of added alloy elements and has an oxygen concentration of 300 mass ppm or less, and the case having a structure being inhibited in cavity formation during the superplastic forming is inhibited.

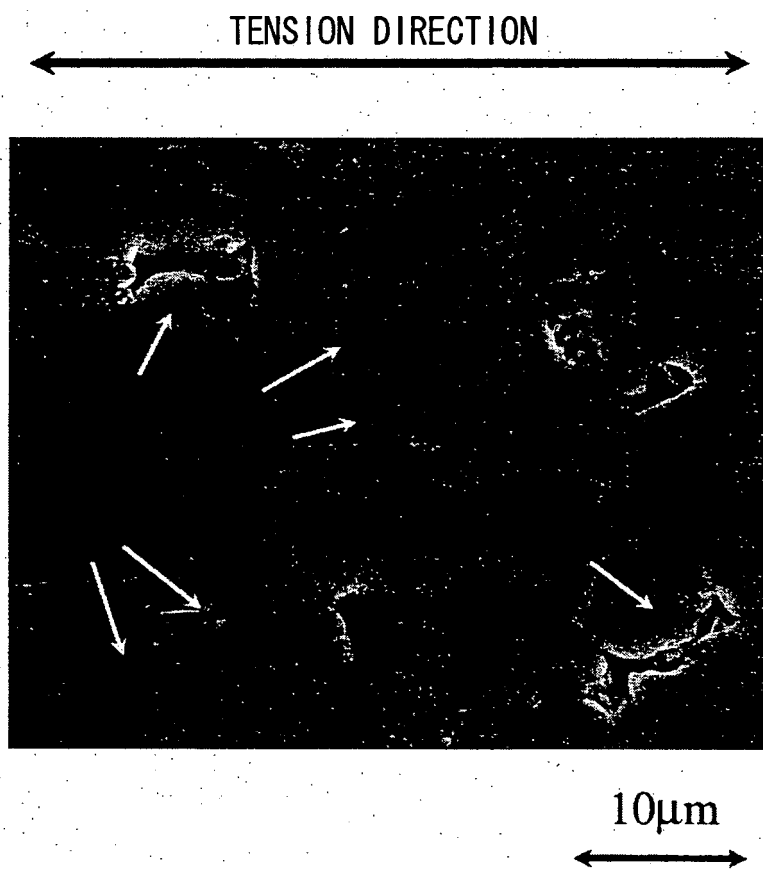
- 5 **2.** The magnesium alloy case according to claim 1, wherein the case comprises a superplastically formed body of the magnesium alloy sheet material having an oxygen concentration of 100 mass ppm or less.
- 10 **3.** The magnesium alloy case according to claim 1 or 2, wherein some portions of the magnesium alloy sheet material are formed through the superplastic forming.
- 15 **4.** The magnesium alloy case according to claim 3, wherein the superplastic forming is a deep drawing.
- 5.** The magnesium alloy case according to claim 3, wherein the superplastic forming is a stretch forming.
- 20 **6.** The magnesium alloy case according to claim 3, wherein the superplastic forming is a blow forming.
- 7.** The magnesium alloy case according to any one of claims 1 to 6, wherein some crystal grains of the magnesium alloy case have a size of 20 μm or less.
- 25 **8.** A lightweight structural member **characterized by** comprising the magnesium alloy case defined in any one of claims 1 to 7.
- 30
- 35
- 40
- 45
- 50
- 55



F i g . 1



F i g . 2



F i g . 3

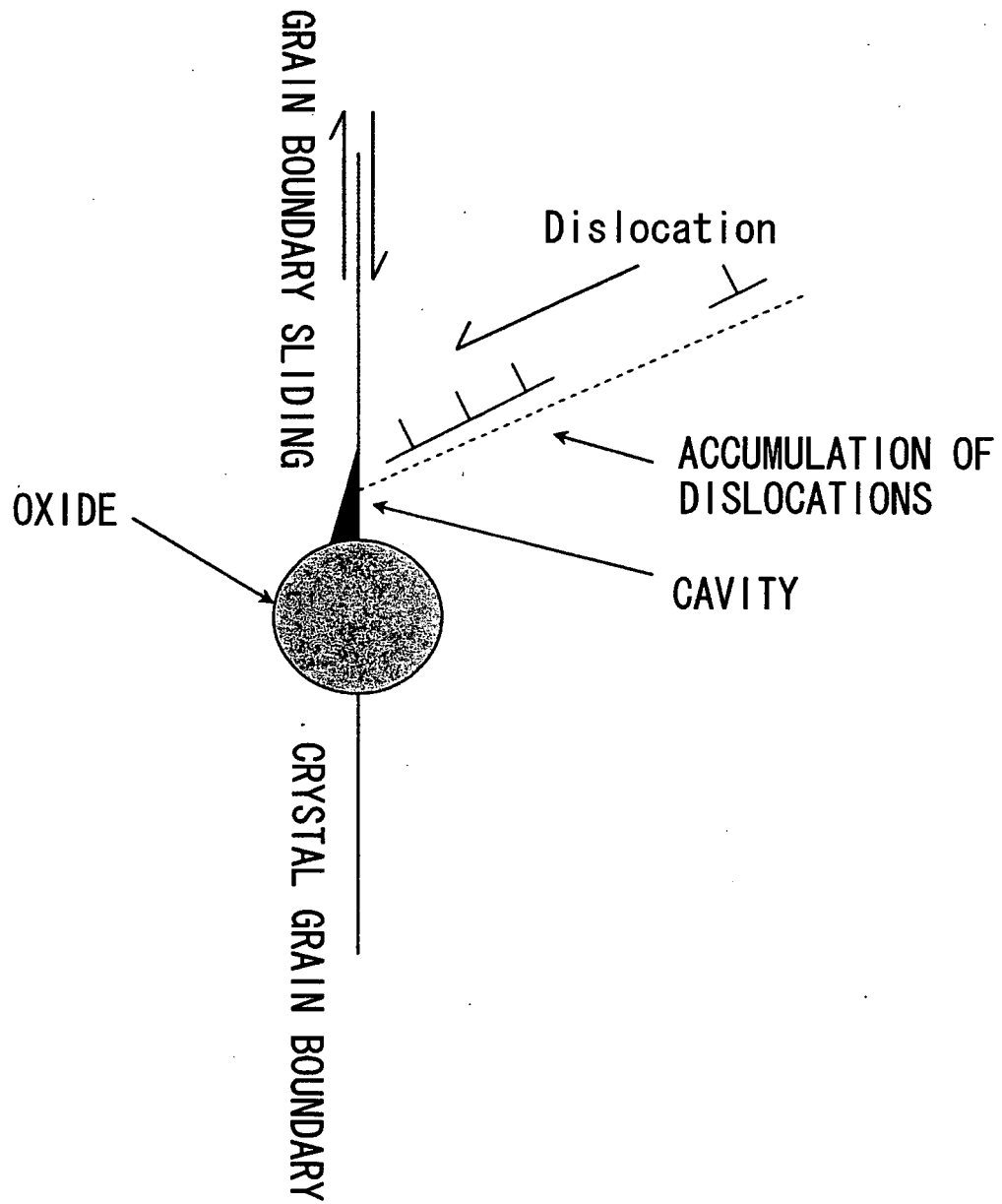
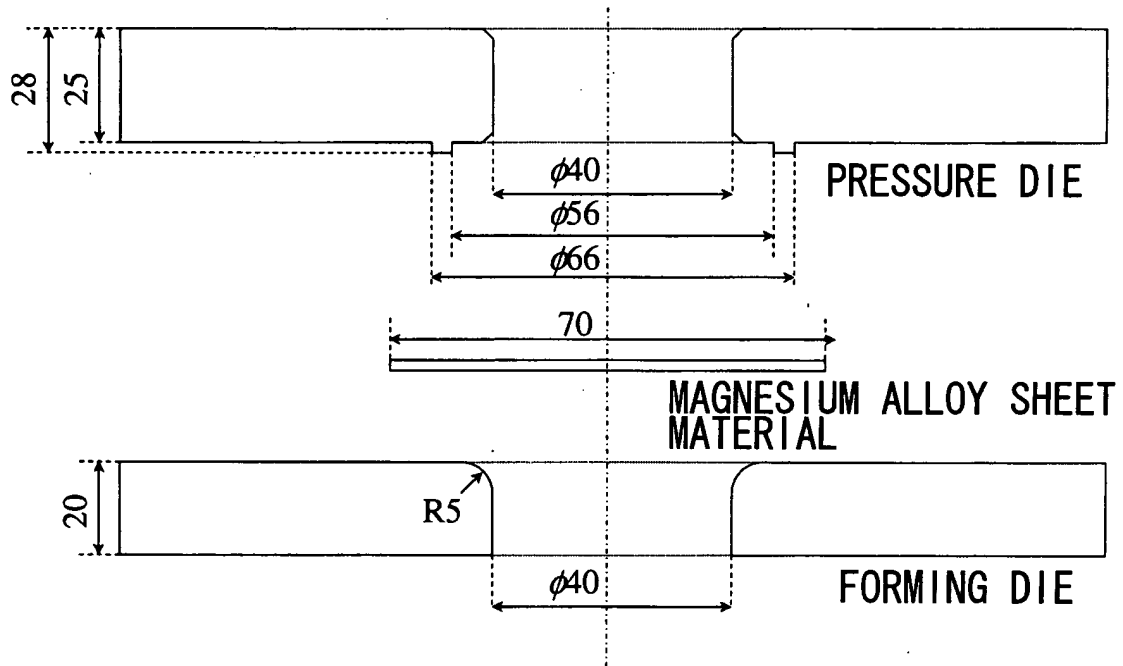
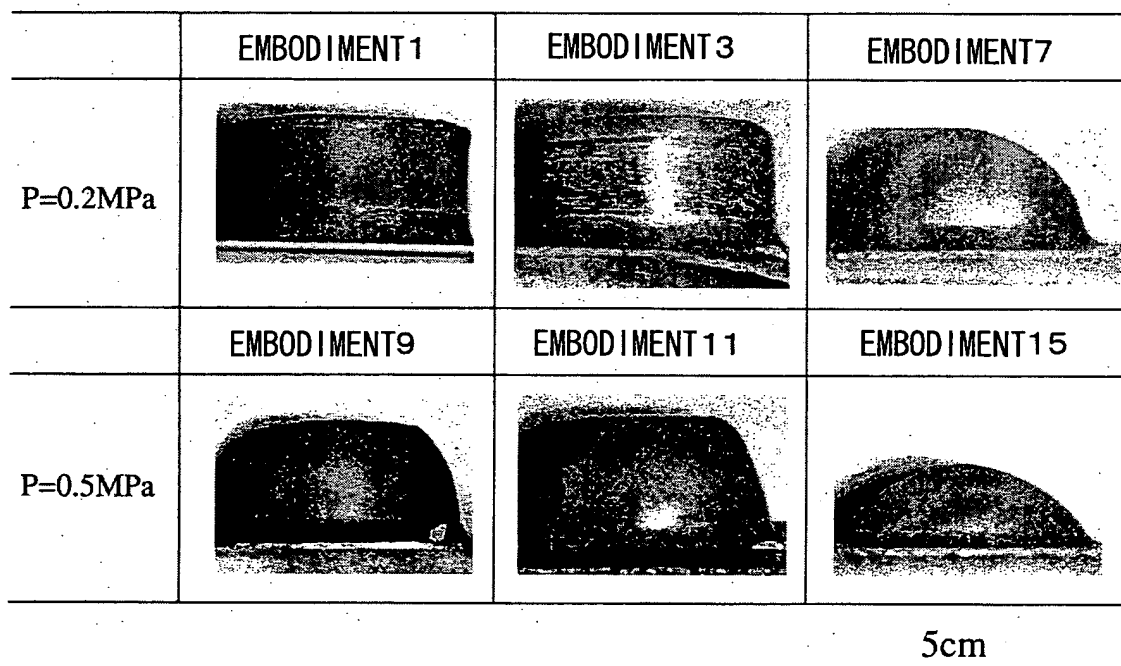


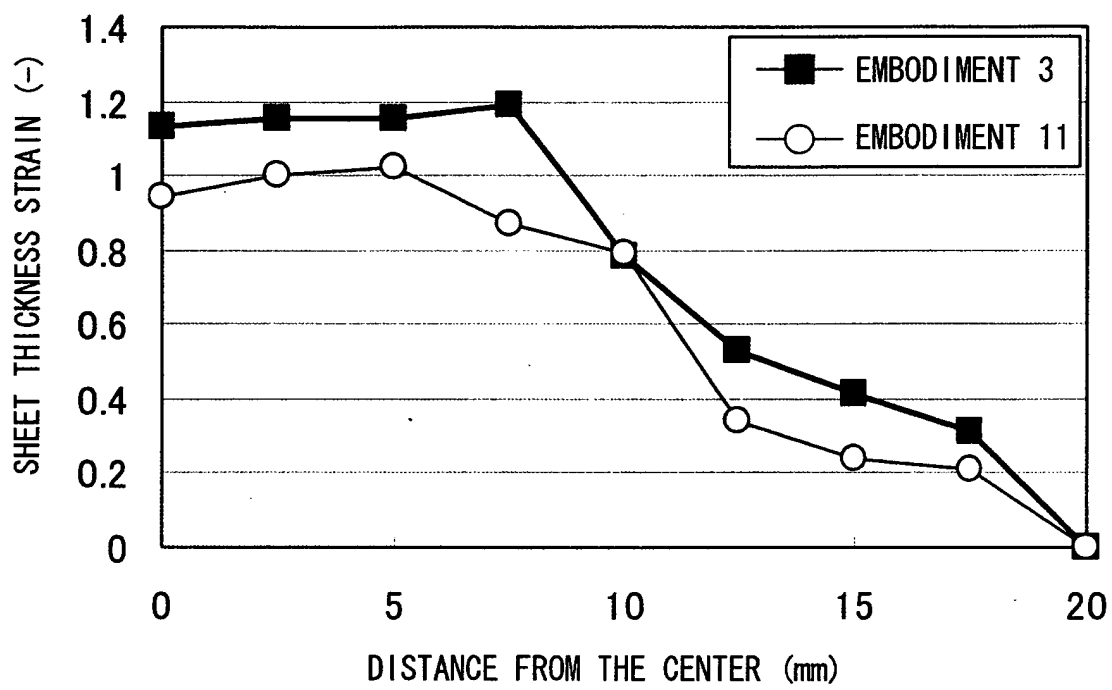
Fig. 4



F i g . 5



F i g . 6



F i g . 7

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2005/001363

A. CLASSIFICATION OF SUBJECT MATTER Int.Cl. ⁷ C22C23/02		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols) Int.Cl. ⁷ C22C23/00-23/06		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2005 Kokai Jitsuyo Shinan Koho 1971-2005 Toroku Jitsuyo Shinan Koho 1994-2005		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Yasumasa SENNO et al., "Magnesium Gokin In-house Scrap-zai no Kotai Recycle", Materia Japan, 20 April, 2004 (20.04.04), Vol.43, No.4, pages 270 to 274	1-8
A	Hiroyuki FUJII, "Magnesium Seizo Gijutsu to Press Kako Gijutsu", Alutopia, 2002, Vol.32, No.2, pages 16 to 20	1-8
A	JP 2003-239033 A (Matsushita Electric Industrial Co., Ltd.), 27 August, 2003 (27.08.03), Claims & US 2003-159797 A1 & CN 1424418 A	1-8
☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search 18 April, 2005 (18.04.05)		Date of mailing of the international search report 10 May, 2005 (10.05.05)
Name and mailing address of the ISA/ Japanese Patent Office		Authorized officer
Facsimile No.		Telephone No.

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2004149841 A [0006]
- JP 2003311360 A [0006]
- JP 2000126827 A [0006]
- JP 2004058111 A [0006]

Non-patent literature cited in the description

- **M. MABUCHI et al.** Tensile Properties at Room Temperature to 823 K of Mg-4Y-3RE Alloy. *Mater. Trans.*, 2002, vol. 43, 2063-2068 [0007]