

Microstructural And Mechanical Studies In Al-Mg Based Alloys Obtained By Conventional And P/M Processes After Special Thermomechanical Treatments

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Abstract. Al-Mg based alloys have special attention due to the lightness of the material and certain mechanical properties and recyclability. Normally classified as non-heat-treatable these alloys obtain higher strength either by strain-hardening or by solid solution. The P/M process in the Al-Mg alloys in study leading to fine grain structure after the thermal treatment. The direct observation were made in a JEOL 200C and 2010 TEM combined with mechanical characterization utilizing Vickers microhardness measurements. The samples preparation followed the usual route of metallographic specimen preparation. The understanding of the observed phenomena depends of the fact that materials produced by powder metallurgy present complex interface reactions in a great amount of nucleation sites and a subtle change in the structure of the material causes an important variation in your properties. Alloys in study presented interesting values of properties, with evident technological potential.

Introduction

Al-Mg alloys have special attention due to the lightness of the material and certain mechanical properties, their application is in a range from components of pieces in the automobile up to that in the naval and aerospace industries. Some of the criteria for selection of those materials for structural applications are: specific mechanical resistance (resistance-weight ratio) and the specific rigidity, that differs among the several materials of light alloys. The recyclability of the aluminum alloys is one factor of special interest nowadays. [1-3]

The interaction processes among crystalline and precipitate defects are of fundamental interest in the recovery and recrystallization processes in metallic alloys. Materials, such the aluminum alloys, when at high deformation degrees, create an amount of crystalline defects that provide them certain mechanical properties. The analysis of the degree of crystalline defects is, in many cases, indirectly observed, through mechanical test, such as microhardness analysis. However the production of such alloys by P/M technique lead to fine grain structure and the understanding of the some observed phenomena during the processes of recovery and recrystallization depends, mainly, to the fact that those materials present complex interface in a great amount of nucleation sites and a subtle change in the structure of materials will cause important variation in their properties. [4,5]

Experimental Procedure

The material in study, bars of Al-2Mg-0,6Zr, Al-4Mg-0,6Zr and Al-2Mg-1Nb was obtained by the technique of processing of the material in form of particles in mill of high energy (by 2 hours in recipient of Polyethylene of the type UHMW - Ultra-High Molecular Weight) and with steel spheres.) followed by uniaxial compression in vacuum and hot extrusion (with temperature for both processes of 723 K and the pressures were 400 MPa in hot compaction process and 60 MPa in extrusion process). Aluminum powder was supplied with medium granulometry of 25 μm . Magnesium and niobium were supplied in form of bars, and the material was filed for removal of

shavings, with size of the order of millimetres. Zirconium was supplied in sponge state, being necessary the previous preparation of the powder, that was done by the subsequent break of the material (mechanical processing that began with the break in small parts of the sponge and it finished in the high energy mill) until reaching the form of a powder, for the subsequent addition in the alloy. These processes were made in the Laboratory of Powder Metallurgy of the Materials Science and Technology Center of IPEN/USP. After the process of compaction and extrusion the alloy was 89% cold worked, and then annealed at 473 to 623 K range, up to 6000 s of time treatment.

Following the process of analysis, microhardness measurements were made in to verify possible mechanical improvements.

Samples were prepared for observation by transmission electron microscopy, which process of preparation followed the usual route. The samples were observed to the microscope JEOL JEM200C and 2010TM in the Materials Science and Technology Center of IPEN/USP.

Results and Discussion

The transmission electron microscopy shows an evolution on the microstructure in the samples in study. The figure 1. show a great dispersion of fine precipitates, little influence of the treatment temperature in the structural condition in the Al-Mg-Nb alloy, figure 2 show the evolution of the microstructure and precipitates interactions in the samples of Al-2Mg-0,6Zr and figure 3 show the same processes on the Al-4Mg-0,6Zr alloys samples. The precipitates present in the Al-Mg-Nb alloy show round format, with very different dimensions to each other, not presenting appreciable amounts of niobium. The occurrence of this phenomenon is owed to a very fine precipitation of NbAl₃ (in order of 20 nm) in the contour of these larger precipitates. However in the Al-Mg-Zr alloys, this rounded shape does not occur, but a formation of a complex structure with an aggregation of one or more fine precipitates, making fine precipitates distributed inside the grains and crystalline defects, like dislocations, interacting with precipitates. Is observed, also in the micrographies, an evolution on the shape and grain size and an high resolution image of one of the precipitates.

Figure 4 the curves of microhardness of the samples in study after 6000 s of time of treatment at several temperatures, which show a loss of hardness with the increase of temperature of thermal treatment.

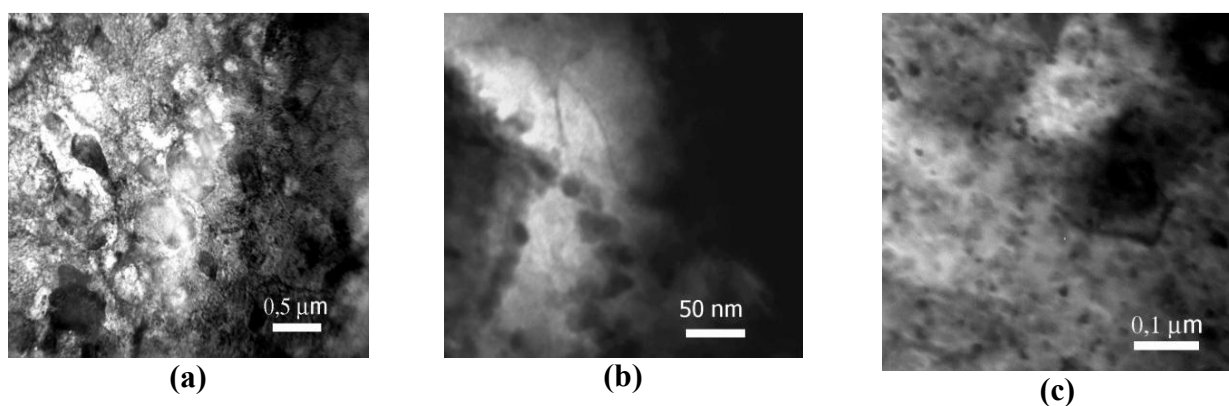


Figure 1. Transmission electron microscopy of Al-2Mg-1Nb (weight values) alloy, produced by powder metallurgy (hot compactation and extrusion technique), 89% cold worked, and annealed, show at: (a) 373 K (60 s) fine precipitates inside the grains and high degree of crystalline defects, (b) 373 K (600 s) bands of dislocations interacting both with each other and precipitates, (c) 673 K (6000 s) precipitates with round format, with very different dimensions to each other.

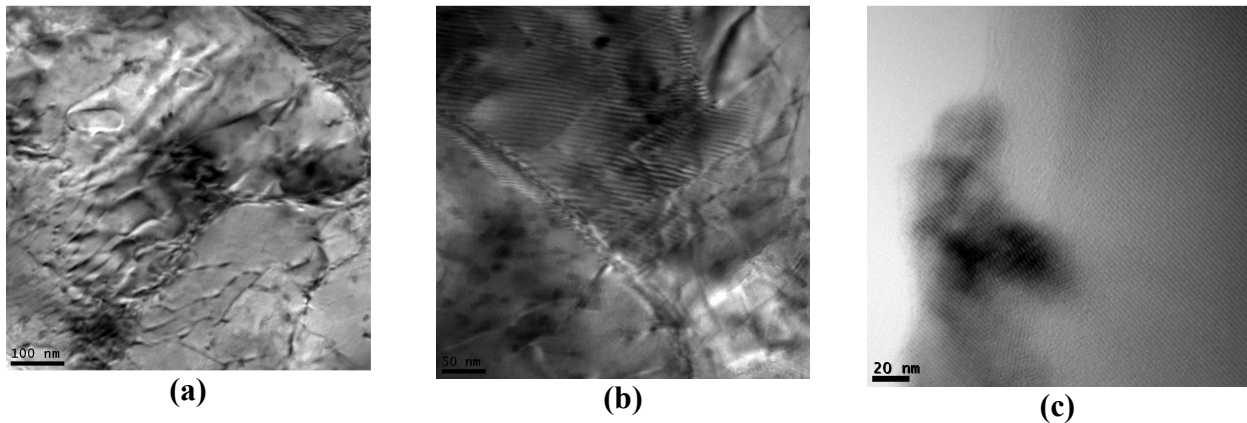


Figure 2. Transmission electron microscopy of Al-2Mg-0.6Zr (weight values) alloy, produced by powder metallurgy (hot compactation and extrusion technique), 89% cold worked, and then annealed, show at: (a) 423 K (60 s) fine precipitates inside the grains and crystalline defects, (b) 423 K (300 s) bands of dislocations interacting both with each other and precipitates, (c) high resolution image of a fine precipitate.

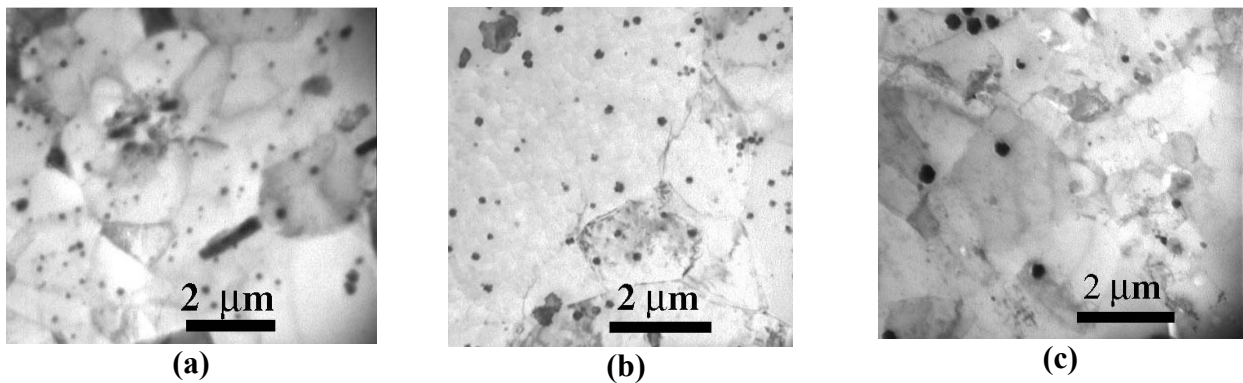


Figure 3. Transmission electron microscopy of Al-4Mg-0.6Zr (weight values) alloy, produced by powder metallurgy (hot compactation and extrusion technique), 89% cold worked, and then annealed, show at: (a) 623 K (600 s) fine precipitates inside grains and crystalline defects, (b) 723 K (60 s) dislocations interacting with each precipitates and precipitates inside grains, (c) 823 K (60 s) precipitates between grains region and crystalline defects.

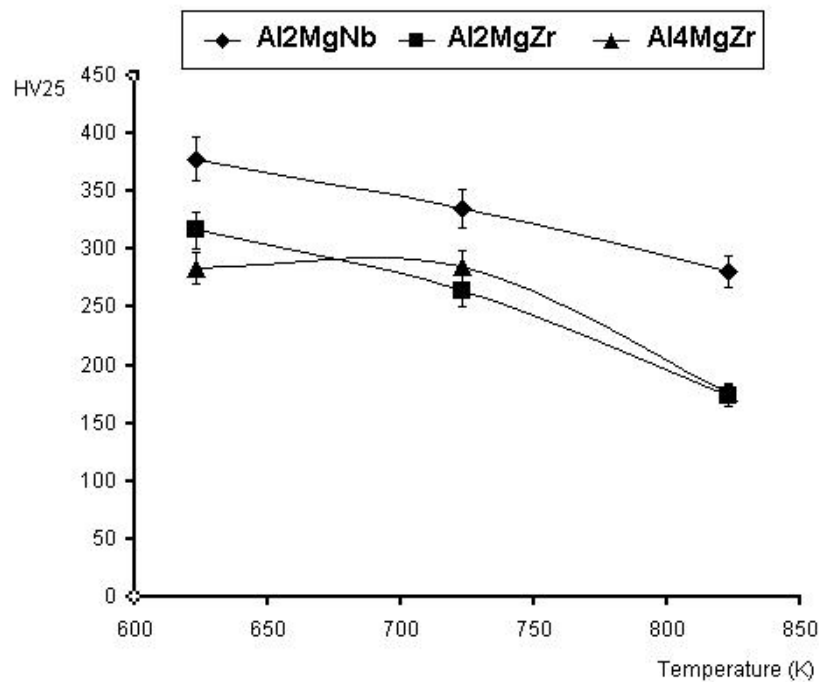


Figure 4. Curve of microhardness analysis of samples of Al-2Mg-1Nb, Al-2Mg-0.6Zr and Al-4Mg-0,6Zr (weight values) alloy, produced by powder metallurgy (hot compactation and extrusion technique), 89% cold worked, and them annealed for 6000 s at several different temperatures.

Conclusions

The TEM analysis could help us to understand some important aspects of the phase transformations, which leads to the processes of recovery and/or recrystallization. However, in the alloys produced by P/M in study, shows interactions between fine precipitates and crystal defects, precipitate distributions interacting with dislocations, annihilation of dislocation and the evolution in the form and size of the grains indicating that the processes of recovery and/or recrystallization of the alloys in study highly depends on the fact that those materials present complex interface reactions in a great amount of nucleation sites and changes in the structure of the material causes an important variation in your properties as observed in the hardness. In this study, were observed decreases of hardness with the increase of the treatment temperature, with final experimental hardness, after 6000 s of time of treatment in temperature of 823 K, around 180 HV25 for the alloys Al-2Mg-0,6Zr and Al-4Mg-0,6Zr and 300 HV25 for the alloy Al-2Mg-1Nb. The variation among the parameters of the this kinetics are due to the differences of chemical composition, since the other processing parameters were maintained.

Acknowledgements

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