

CRYSTALLIZATION OF $Mg_{80}Ni_{10}CeMM_{10}$ AND $Mg_{80}Ni_{10}Y_5CeMM_5$ AMORPHOUS ALLOYS



S. González (sergiogs@cenim.csic.es), P. Pérez, G. Garcés and P. Adeva

Dept. of Physical Metallurgy,
National Center for Metallurgical Research (CENIM) CSIC,
Avda. Gregorio del Amo, 8. 28040 Madrid, Spain.

1. General Abstract

Magnesium is used for automotive and aerospace components due to its high specific strength. There is an increasing interest to study Mg-based amorphous alloys because their mechanical properties are higher than those corresponding to crystalline alloys with the same composition. These amorphous alloys are also promising as hydrogen storage materials.

2. Technical Abstract

The addition of Ni, Y and RE elements in certain proportions to pure magnesium permits to stabilize the amorphous structure when it is cooled quickly enough. The cost of the alloys could be reduced by replacing pure RE with mischmetal (MM). Crystallization of the initially amorphous ribbons takes place in several stages involving the formation of intermediate phases. A long period ordered structure crystallizes when CeMM is substituted by yttrium.

3. Experimental procedure

Alloys:

$Mg_{80}Ni_{10}CeMM_{10}$ (at. %)
 $Mg_{80}Ni_{10}Y_5CeMM_5$ (at. %)

CeMM (53 wt. % Ce, 26 wt. % La, 16 wt. % Nd, 5 wt. % Pr).



Melt-spining

- Ribbons:

$Mg_{80}Ni_{10}CeMM_{10}$
1 mm x 0.0364 mm

$Mg_{80}Ni_{10}Y_5CeMM_5$
1.96 mm x 0.0311 mm

Characterization techniques for crystallization studies:

- Differential Scanning Calorimetry (DSC).
- Scanning electron microscopy (SEM) with an energy dispersive X-ray analysis (EDX), X-ray diffraction (XRD) and transmission electron microscopy (TEM).
- Vickers microhardness tests (HV).

4. Results

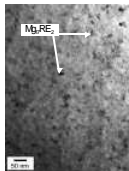


Fig.1. TEM micrograph after the first DSC peak showing the $Mg_{17}RE_2$ nanocrystals.

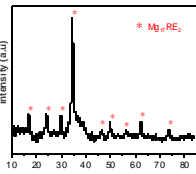


Fig.2.XRD after the first DSC peak

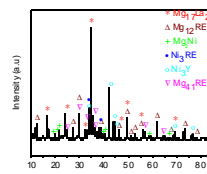


Fig.3.XRD at the end of the DSC.

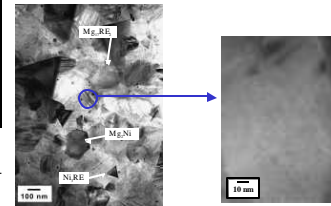
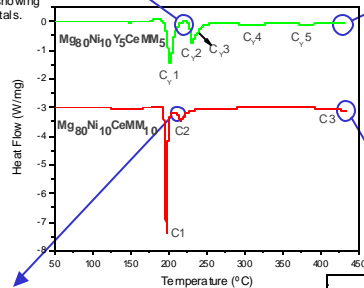


Fig.4. TEM micrograph at the end of the DSC curve showing $Mg_{17}RE_2$ and Ni_6RE particles embedded in the $Mg_{17}RE_2$ matrix.

Fig.5. Bright field TEM micrograph of the lamellar arrangement in the LPSO phase at the end of the DSC curve.



5. Conclusions

- Crystallization of the two alloys takes place in several steps.
- Crystallization of both alloys gives rise to a nanocrystalline matrix of $Mg_{17}RE_2$ embedding other intermetallics phases.
- The substitution of CeMM by Y shifts the crystallization temperature to higher temperatures. Therefore Y stabilizes the amorphous phase.
- During the crystallization of the alloy containing yttrium, the supersaturated magnesium nanocrystals adopt the configuration of a LPSO structure.
- The origin of the phase transformations that occur during the heating is the presence of phases supersaturated in different alloying elements.

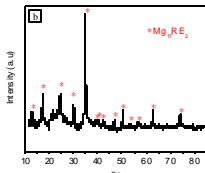
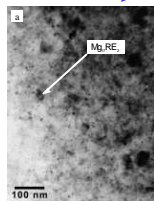


Fig.6. a) TEM micrograph showing $Mg_{17}RE_2$ nanocrystals and b) XRD after the first DSC peak.

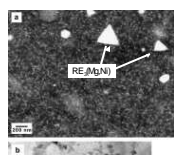


Fig.7. a) Backscattered SEM and b) TEM micrographs at the end of the DSC. The big and small triangular particles correspond to $RE_2(Mg,Ni)$ and Ni_6RE , respectively. The matrix correspond to $Mg_{17}RE_2$.

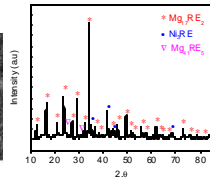


Fig.8 XRD at the end of the DSC.

6. Glossary

Melt-spining: A rapid solidification technique which consists of a copper wheel rotating at high velocity. This configuration acts as an efficient heat sink for the injected melted alloy, so cooling rates 10^4 to 10^7 K/s can be achieved.

LPSO (Long-period stacking ordered structure): It is the structure with the atoms in a stacking sequence of closely packed planes.

Intermetallics (inter metallic compounds): Two or more chemical elements (except oxygen, halides and noble gases) with a crystal structure different than that of its constituent elements. It has a long range order and possesses a characteristic specific composition or a narrow composition range.

Mischmetal: From German: Mischmetall-"mixed metals". Alloy consisting of the mixture of rare-earth elements in various naturally-occurring proportions.

Crystallization: The formation of crystals from the initially metastable amorphous alloy when the heating is enough to provide sufficient atomic mobility.

Nanocrystal: Crystalline materials with grain sizes smaller than 100 nm.