DOI: 10.1017/S1431927605502320
Microsc Microanal 11(Suppl 2), 2005

Lorentz TEM Characterization of Al-Cu-Ge-Mn Alloys

J.P. Winer, N.T. Nuhfer, M.E. McHenry, and M. De Graef

Department of Materials Science & Engineering, Carnegie Mellon University, Pittsburgh, PA 15213

The discovery of magnetic quasicrystalline materials with a Curie temperature about room temperature in 1988 [1] has prompted a number of studies on the magnetic behavior of these alloys. In particular, the magnetic behavior of $Al_{40}Cu_{10}Mn_{25}Ge_{25}$, which exhibits both the icosahedral and decagonal phases, has been extensively characterized [2]. Rapidly solidified alloys around this composition exhibit two phases, a tetragonal AlGeMn phase [3], which is ferromagnetic with a Curie temperature of 519 K, and a quasicrystalline phase, that is reported to be ferromagnetic [1]. The goal of this research is to fabricate these magnetic quasicrystals and to determine the presence of magnetic domain walls in either or both of the phases by means of Lorentz transmission electron microscopy (LTEM).

Four alloy ingots with composition $Al_{(50-2y).8}Cu_{(50-2y).2}Mn_{25+y}Ge_{25+y}$, where y is 0.00, 1.25, 2.5 or 3.75, were prepared by arc welding elements of high purity (99.99%). Rapidly cooled flakes were produced from two of the ingots (Alloy 1 $y = 3.75$ and Alloy 2 $y = 0$) by a single wheel melt spinner rotating at 40 m/s. One flake from each sample was thinned for transmission electron microscopy using a Gatan Precision Ion Polishing unit. Lorentz microscopy was performed on a Jeol 2000EX, a Tecnai F20 and a Jeol 4000EX. Powder x-ray diffractometry was performed using Cu-Kα radiation. Interference between the Cu-Kα source and the copper in the sample accounts for the appreciable background. Lastly, magnetization versus temperature was recorded using a vibrating sample magnetometer in the temperature range of 30 to 600 K.

X-ray powder diffractograms of the two alloys are shown in Fig. 1 along with a simulated pattern of the intermetallic AlGeMn phase. The patterns were indexed using the method described by Bancel et al. [4]. Many of the quasicrystal reflections coincide with those of the AlGeMn phase. The magnetic moment as a function of temperature is shown in Fig. 2 (in a non-saturating 100 Oe field); the Curie temperature agrees with that reported for the AlGeMn phase [3]. The sample clearly shows a quasicrystalline phase, as illustrated by the five-fold electron diffraction pattern in Fig. 3. Lorentz images are shown in Fig. 4; the in-focus images shows several grains, and magnetic domain contrast is visible in the upper grain of the underfocus and overfocus Fresnel images. Due to the electron optical conditions used for Lorentz observations electron diffraction patterns could not be obtained, hence an unambiguous phase identification of the grains in Fig. 4 could not be obtained. Further characterization efforts are currently underway.

References

1. A.-P. Tsai, A. Inoue, T. Matsumoto, & N.J. Kataoka, Appl. Phys., 27 (1988) L2252.
2. R. Chatterjee, A. Kanjilal, R.A. Dunlap, & O.N. Srivastava, Mat. Let., 57 (2002) 689.
3. N.S. Satya Muthy, R.J. Begum, C.S. Somanathan & M.R.L.N. Murthy, JAP 40 (1969) 1870.
4. P.A. Bancel, P.A. Heinery, P.W. Stephens, A.I. Goldman, & P.M. Horn, PRL, 54 (1985) 2422.
5. JPW was supported by an MSA Student Scholarship. Other financial support was provided by the U.S. National Science Foundation (DMR-0404836).

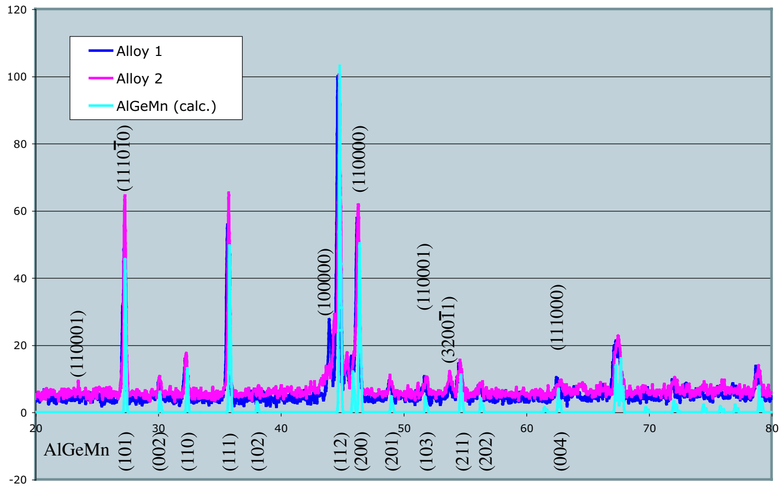

FIG. 1. The intensity versus 2θ of the two alloys, $Al_{40}Cu_{10}Mn_{25}Ge_{25}$ and $Al_{34}Cu_{8.5}Mn_{28.75}Ge_{28.75}$, indexed using the method described by Bancel et al. [4].

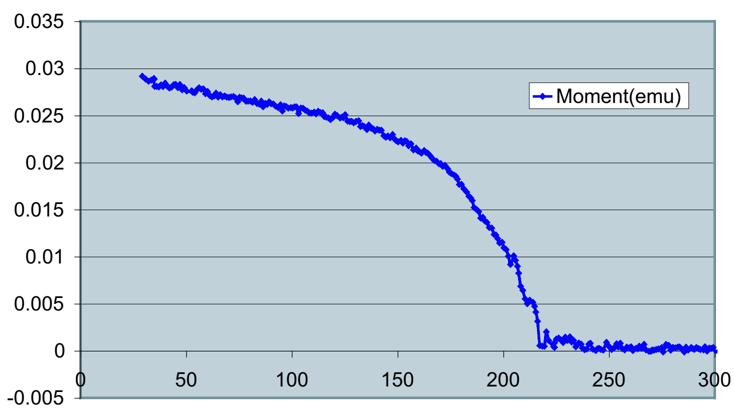

FIG. 2. Vibrating sample magnetometer data (magnetic dipole moment as a function of temperature) in a 100 Oersted applied field ($Al_{40}Cu_{10}Mn_{25}Ge_{25}$).

FIG. 3. Selected Area Diffraction Pattern of rapidly solidified $Al_{40}Cu_{10}Mn_{25}Ge_{25}$ exhibiting five fold symmetry.

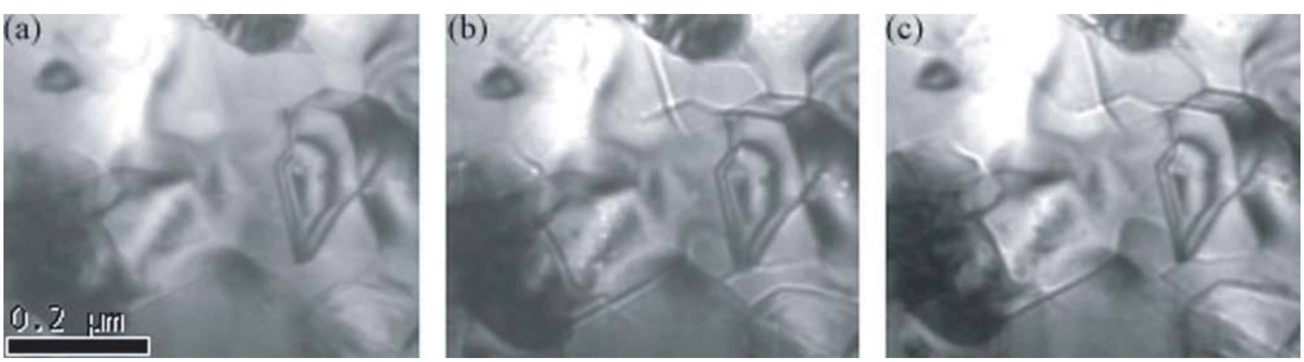

FIG. 4. Fresnel Mode LTEM images (a) in focus image (b) overfocus image (c) underfocus image.

https://doi.org/10.1017/S1431927605502320 Published online by Cambridge University Press