In-Situ Texture Evolution of $Ni_{49.2}Mn_{29.6}Ga_{21.1}$ with Annealing Temperature

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Introduction

Ni-Mn-Ga magnetic shape memory alloys are smart materials that can exhibit large recoverable strains (several %) when subjected to a magnetic field. The strains obtained from these materials are much larger than those from magnetostrictive materials (~ 0.2%) and are comparable to those obtained from conventional shape memory alloys. The strain recovery takes place upon removal of the magnetic field, a process that is faster compares with the shape recovery process in conventional shape memory alloys. Applications of Ni-Mn-Ga based include actuators, positioning devices, sonar devices and robotics.

Conventional shape memory alloys undergo a reversible martensitic transformation when cooled below a critical temperature (the martensite start temperature, M_s), in which a cubic parent phase (austenite) transforms into a tetragonal, orthorhombic or monoclinic martensitic phase. The type of the martensitic structure depends on the chemical composition of the sample. Re-transformation to austenite occurs upon heating and in the case of Ni-Mn-Ga, the austenite phase has a Heusler structure (Figure 1).

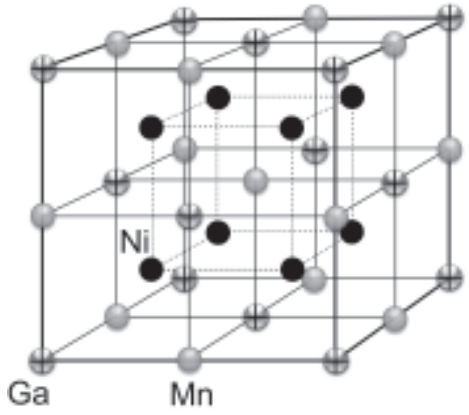

Fig. 1 Austenite (parent phase) of Ni-Mn-Ga.

Ni_2MnGa off-stoichiometric compounds show the largest magnetic shape memory effect. Although Ni-Mn-Ga single crystals have been extensively investigated, there is less work on the behaviour of polycrystalline Ni-Mn-Ga. This report is focused on the investigation of the texture evolution of polycrystalline Ni-Mn-Ga with annealing temperature.

Sample and experimental set-up

The nominal composition of the polycrystalline sample used in the present work was $Ni_{49.2}Mn_{29.6}Ga_{21.1}$. This composition was chosen such that the material is martensitic at room temperature, which is desired for practical applications. The sample's geometry was cylindrical with its length and diameter equal to 1cm.

The neutron diffraction texture measurements were performed at E3 spectrometer at the Canadian Neutron Beam Centre (CNBC) at Chalk River Laboratories. In order to study the evolution of the texture with temperature, a specialized "bulb" furnace was installed on a Eulerian cradle at the spectrometer (Figure 2). The sample was gradually annealed using a Ta heater from the room temperature martensite to austenite and full pole figure data were collected for the major diffraction peaks of the two phases. The sample was in a vacuum of approximately 5×10^{-2} Torr for the duration of experiments.

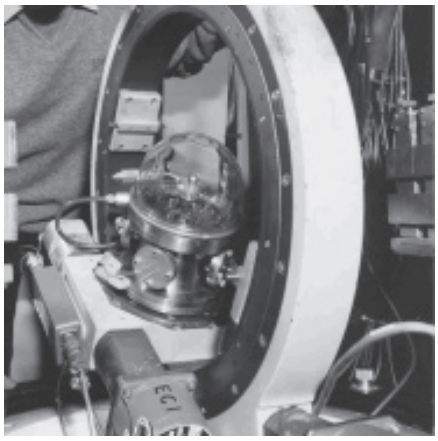

Fig. 2. Photograph of the "bulb" furnace placed on the Eulerian Cradle at the E3 spectrometer at CNBC.

Neutron diffraction pole figures data

Analysis of additional neutron data obtained at the C2 powder diffractometer indicated that the martensite structure is complex and is in fact composed of at least 2 phases. At this writing, the analysis of pole figures from the room temperature martensite is not completed and thus only the austenite data will be discussed in this report.

Figure 3 shows the austenite pole figures for 65 and 85°C. Direction "R" of the pole figures was the reference direction for the measurements and was arbitrarily chosen as one of the diameters of the cylindrical sample.

Interestingly, Figure 3 shows that the austenite texture is changing with temperature, especially in the case of the <200> and <220> crystallographic directions. Further investigation involving an ODF analysis of the pole figures

is required in order to determine the details of this texture evolution.

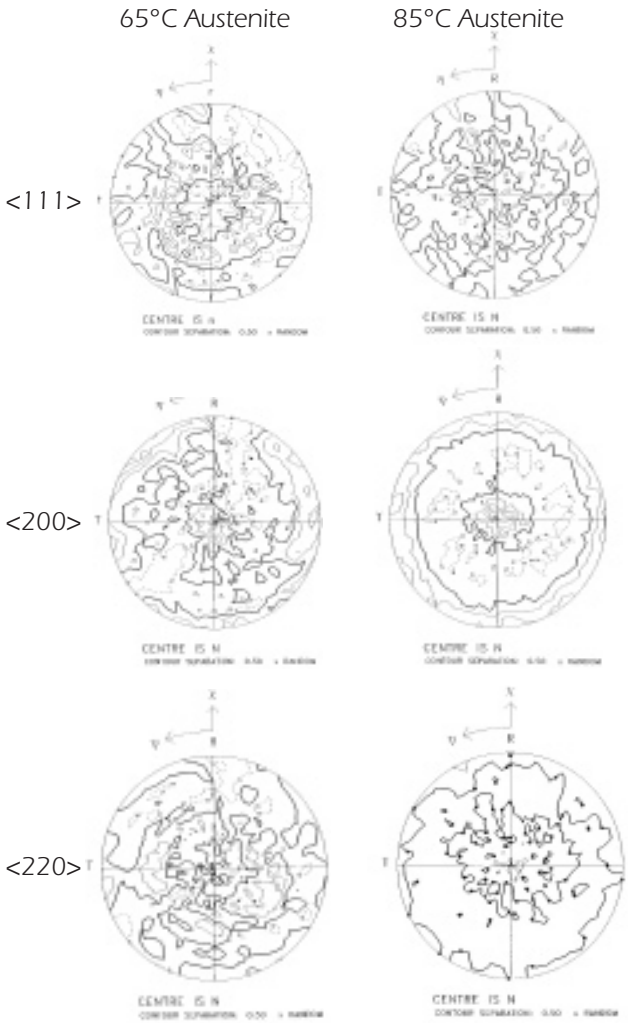

Figure 3. *Austenite <111>, <200> and <220> pole figures at 65 and 85°C.*

Acknowledgements

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