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Antiferrodistortive isostructural phase transition in perovskites

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Magnetic shape memory alloys (MSMAs) owe their functional properties to a martensitic phase transition. Unlike the conventional shape memory alloys, the shape recovery in MSMAs can be realized under the influence of not only the temperature and stress but also the magnetic field. Amongst the MSMAs, stoichiometric Ni2MnGa and off-stoichiometric Heusler alloys in the alloy systems Ni-Mn-Ga (In, Sn, Sb) have received considerable attention. The stoichiometric Ni2MnGa system is by far the most studied system due to its large (10%) magnetic field induced strain (MFIS) with potential applications in novel multifunctional sensor and actuator devices. Ni2MnGa is a multiferroic exhibiting two ferroic order parameters, namely spontaneous magnetization and spontaneous strain, which appear below the ferromagnetic and ferroelastic (martensite) phase transition temperatures Tc ~ 370 K and Tm ~ 210K, respectively. The martensitic transition in Ni2MnGa is preceded by a premartensite phase transition around Tpm= 260K. Both the martensite and premartensite phases exhibit very strong coupling between the two ferroic order parameters (ie, magneto-elastic coupling) as a result of which Ni2MnGa exhibits very large MFIS. The large MFIS is also closely linked with the incommensurate modulated structure of the martensite phase. Since the modulated phase of Ni2MnGa appears via a modulated premartensite phase and not directly from the austenite phase after its Bain distortion, understanding the characteristics of the premartensite phase and its effect on the martensite phase transformation has been a hot topic of research in recent years. The thermodynamic stability of the premartensite phase and its relation to the martensitic phase is still not clear. We present here unambiguous evidence for macroscopic symmetry breaking leading to robust Bain distortion of the premartensite phase in Ni2MnGa MSMA doped with 10% Pt through a high resolution synchrotron x-ray diffraction study. It is shown that the premartensite phase (T2) with robust Bain distortion results from a “cubic” high temperature premartensite phase (T1) that gets formed first from the cubic austenite phase, through an isostructural phase transition. The martensite phase results from the T2 phase with additional Bain distortion. Our results clearly demonstrate that the premartensite phase should not be considered as a precursor state with the preserved symmetry of the cubic austenite phase.

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