Understanding the correlation of structure with martensitic and magnetic transitions in Cu doped NiMnSn based Shape Memory Alloys

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Ni-Mn based Shape Memory Alloys have been an area of continued research interest due to the observance of magneto-structural transitions which lead to interesting properties and hence a wide variety of applications. They are actively employed in magnetic actuators, optical frames, orthodontic wires, prosthetics, robots, bio-medical implants, etc. Stoichiometric Ni\textsubscript{2}MnSn has cubic L\textsubscript{21} type structure in its austenite (room temperature) phase, with Ni, Mn and Sn occupying positions X (0.25,0.25,0.25), Y (0,0,0) and Z (0.5,0.5,0.5), respectively, shown in Fig.1. Non-stoichiometry is a pre-requisite for exhibiting shape-memory effect, and the transformation is believed to be brought about by the additional inter-atomic interactions resulting from this non-stoichiometry. Doping at different sites is a popular mode of chemically inducing disorder in these alloys, bringing about significant changes in the martensitic transition temperature $T_M$. This change has been strongly attributed to changes in e/a (valence electron concentration) ratio brought about by the dopant, coupled with changes in unit cell volume. In this work, we investigate the effect of Cu doping on Ni site in Ni\textsubscript{48}Cu\textsubscript{6}Mn\textsubscript{36}Sn\textsubscript{10}. With this work, we decouple the effect of the two aforementioned factors on $T_M$. We employ temperature-dependent high-resolution synchrotron XRD and XAFS, to shed light on the distortion in structure, thermal evolution of nearest-neighbor bond distances and the Debye Waller Factor in the martensite and austenite phases. By correlating the subtle structural changes with martensite transition, our findings add to a deeper understanding of this transition in these materials.

Fig. 1: Cubic (L\textsubscript{21}) structure of Ni\textsubscript{2}MnSn alloy.