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_2MnSn has cubic $L2_1$ 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 $Ni_{48}Cu_6Mn_{36}Sn_{10}$. 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.
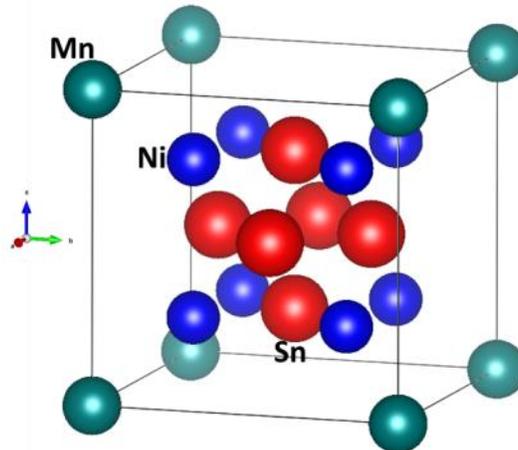

Fig. 1: Cubic (L_{21}) structure of Ni_2MnSn alloy.