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Synergy between structure and magnetism in magnetic shape memory alloys

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Ferromagnetic Shape Memory Alloys (FSMAs) are a group of active materials that undergo martensitic transformations induced by temperature, stress and/or magnetic fields, which result in large recoverable mechanical deformations. Their fast response and high energy density makes them ideal candidates for implementation in sensors and actuators. The magnetic properties of FSMAs depend on the interactions between the magnetic moments of atoms that, in turn, depend on the atomic positions within the lattice. Here we present a combination of powder neutron diffraction experiments in a series of polycrystalline samples of 6-element FSMAs with varied Fe content, where the alloys present actuation at temperatures around 370 K. Their atomic site occupancies, the ratio c/a and, therefore, the maximum achievable deformation are calculated for each alloy. Based on the atomic site occupancies and additional measurements of the saturation magnetization in each sample, the influence of the structure and atomic site occupancies on the magnetism in these samples is presented. This study is complemented by single crystal polarized and non-polarized neutron diffraction experiments in one of the samples used for the powder neutron diffraction measurements, from which a single crystal was grown. Together with the atomic site occupancies in the single crystal, the analysis of the polarized neutron diffraction measurements provides us with information about the magnetic moment distribution in each atomic position present in the unit cell of the single crystal. Finally, the element-specific magnetic moments contribution to the magnetism of the alloy are depicted via X-ray magnetic circular dichroism (XMCD) measurements. The combination of the polarized neutron diffraction and XMCD measurements allows us to unravel element and site-specific magnetic moment distributions in the alloy.

Primary author: PORRO AZPIAZU, Jose Maria (BCMaterials)

Presenter: PORRO AZPIAZU, Jose Maria (BCMaterials)

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