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The recent years have seen a reawakened interest in FeCo alloys due to the increased demands of modern electrical power generation and distribution equipment. For industrial application the challenge involves increasing the tensile strength and ductility of FeCo alloys while maintaining an acceptable balance of magnetic properties (brittleness).
The effects of alloying FeCo with Pt, Pd, etc. have been investigated by neutron diffraction as part of this work. In the composition range of about 30% Co, ternary FeCo alloys undergo a continuous order-disorder phase transformation in the temperature range of 615±30°C [1]. Whereas the T_c temperature is independent of the thermal history, the microstructure of ordered domains is sensitively dependent on thermal history and on the kinetics of the order/disorder transition.
Neutron diffraction is the adapted method to study the order process due to the favourable different scattering length density of Fe and Co. It allows easy distinction between the two elements in a common structure in comparison to X-rays.
Measurements on the alloy system were performed at the neutron facility Forschungsneutronenquelle Heinz Maier-Leibnitz (FRM II). The high temperature measurements to follow the order-disorder phase transition were performed on the diffractometer STRESS-SPEC equipped with a 2-dimensional area detector covering around 15° in 2θ diffraction angle. This allowed following in situ the evolution of a superlattice reflection and a fundamental Bragg reflection in the temperature region T = 25–700°C. The samples were mounted in a high temperature vacuum furnace with aluminium windows to avoid air scattering and oxidation of the sample. The furnace was installed on the sample table of StressSpec, just after the collimator and close to the detector.
Samples of FeCo with different ternary elements were heat treated and cooled down together in a furnace, and in addition samples of the same composition were cooled down with different cooling rates.
Samples with the same cooling rates prepared in thin disc shape of 1 mm thickness were used for defect measurements at the positron facility NEPOMUC (FRM II) which delivers 9 x 10^8 positrons /sec at 1 keV beam energy. The beam energy was set up to 24 keV in order to study the bulk defect concentration in dependence on cooling rate and composition of the alloy.

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Effect of atomic order in ferromagnetic shape memory alloys studied by neutron diffraction.

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The contrast provided by neutron radiation for elements with similar atomic number and the possibility of using bulk samples, in which the properties induced by thermal treatments remain unchanged (which is not the case in powder samples) makes of single crystal neutron diffraction a valuable tool in fields like Ferromagnetic Shape Memory Alloys (FSMA).
FSMA have awakened a great interest in recent years for practical application in sensors and actuators due to the achievement of huge magnetic-field-induced strains (MFIS). The MFIS effect is associated with the rearrangement, under an applied magnetic field, of the crystallographic domains (twin variants) formed as a result of a thermoelastic Martensitic Transformation (MT) taking place from a high symmetry high temperature phase (austenite) to a lower symmetry low temperature phase (martensite).Up to now, the highest MFIS has been observed in Ni-Mn-Ga alloys close to the stoichiometric composition Ni_2MnGa (regarded as the prototypical FSMA system). The modification of the atomic ordering highly affects both the MT and the magnetic properties of the Ni-Mn-Ga alloy and one of the easiest ways of modifying the atomic order in a controlled manner is performing thermal treatments.
The correlation between the L21 atomic order degree and the MT and Curie temperatures on both polycrystalline and single-crystalline alloys subjected to different thermal treatments has been studied by single-crystal and powder neutron diffraction together with calorimetric and magnetic measurements. It is found that both transformation temperatures show exactly the same linear dependence on the degree of L_{21} atomic order, pointing out a high influence of magnetism on the structural transformation. Furthermore, the calculated correlation between transformation temperatures and atomic order allowed us to quantitatively determine the effect of atomic order on the relative stability between the structural phases. [1]

[1] Sánchez-Alarcos, V., Pérez-Landazábal, J.I., Recarte V., Gómez-Polo, C., Rodríguez-Velamazán, J.A., Chernenko, V.A., *J. Phys.: Condens. Matter,* 2010, 22, 166001.

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