Experimental report

20/05/2024

Proposal: **CRG-3054**

Council: 4/2023

Title: Unravelling the Phase Coexistence Interaction During the Magnetoelastic Phase Transition in Fe100-xRhx Alloys

Research area:

This proposal is a new proposal

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Samples: Fe49Rh51/Fe50Rh50

Instrument	Requested days	Allocated days	From	To
D1B	3	2	27/09/2023	29/09/2023

Abstract:

Report Proposal CRG-3054

The magnetocaloric (MC) effect occurs due to the coupling between the magnetic and thermal properties of a material. $Fe_{100-x}Rh_x$ alloys with $48 \leq x \leq 52$ at. % are MC materials of significant interest due to their sharp changes in magnetization and the largest adiabatic changes in temperature reported to date [1]. Within this composition range, the Fe-Rh alloys crystallize in the CsCl-type crystal structure (B2 structure) and undergo a temperature- and magnetically-driven magnetostructural first-order phase transition (FOPT). The features of this transition are consequence of the competition between the antiferromagnetic (AFM) and ferromagnetic (FM) phases in the context of a complex nucleation process [2]. Unfortunately, the practical application of this first-order MC material is limited by its thermal hysteresis, since it reduces the reversibility negatively affecting its cyclic operation performance [3]. Hence, unveiling the interaction of both AFM and FM magnetic phases result to be fundamental in optimizing its MC properties. To analyze the interaction between the two phases, the temperature first-order reversal curves (T-FORC) distributions can provide meaningful information [4]. The T-FORC distribution is defined as the mixed second derivative of the magnetization with respect to the temperature and the return temperature. But, neutron diffraction (ND) T-FORC experiment allows to define it as the mixed second derivative of the cell parameter with respect to the temperature and the return temperature. Due to the limited allocated beam-time (2 days, 3 days requested), we measured the sample $Fe_{49}Rh_{51}$. After finding a position where the texture of the bulk sample was less predominant by rotating it around the cane axis with a motor, the thermal protocol show in Figure 1 was followed. The temperature sweep rate was 0.5 K/min and ND patterns where measured every 2 mins. The used wavelength was $\lambda = 2.52$ Å, in the angular range (2θ) between 0º and 128º.

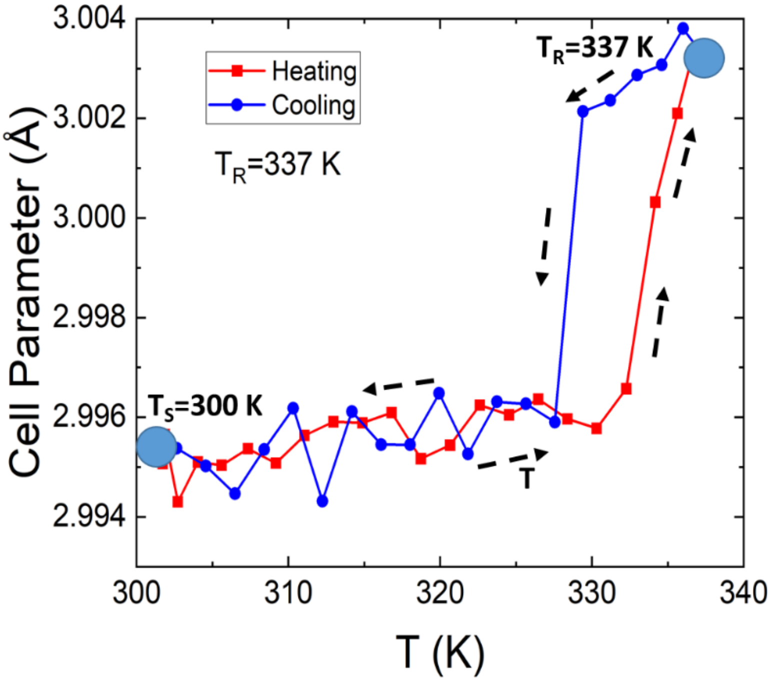

Figure 1. Sketch of the thermal protocol followed on this experiment. T_S and T_R indicate saturation (defined in a state where the sample was in the AFM (FM) when heating (cooling)) and return temperatures, respectively. Selected ND pattern correspond to T_R = 337 K, collected on cooling in ramps from the return temperature (blue curve) after heating from the saturation temperature are also shown (red curve). The arrows indicate the direction of the temperature. The cell parameter was calculated through a Le Bail refinement.

References

[1] F. de Bergevin, L. Muldawer, Compt. Rend. 252 (1961) 1347.

[2] D.J. Keavney et al., Phase Coexistence and Kinetic Arrest in the Magnetostructural Transition of the Ordered Alloy FeRh, Scientific Reports 2018 8:1. 8 (2018) 1–7.

[3] F. Scheibel, T. Gottschall, A. Taubel, M. Fries, K.P. Skokov, A. Terwey, W. Keune, K. Ollefs, H. Wende, M. Farle, M. Acet, O. Gutfleisch, M.E. Gruner, Energy Technol. 6 (2018) 1397–1428.

[4] V. Franco, T. Gottschall, K.P. Skokov, O. Gutfleisch, IEEE Magn. Lett. 7 (2016) 6602904.