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Ion-irradiation-induced rotation of the direction of the collapsed hard axis in thin films presenting recoil-curve overshoot

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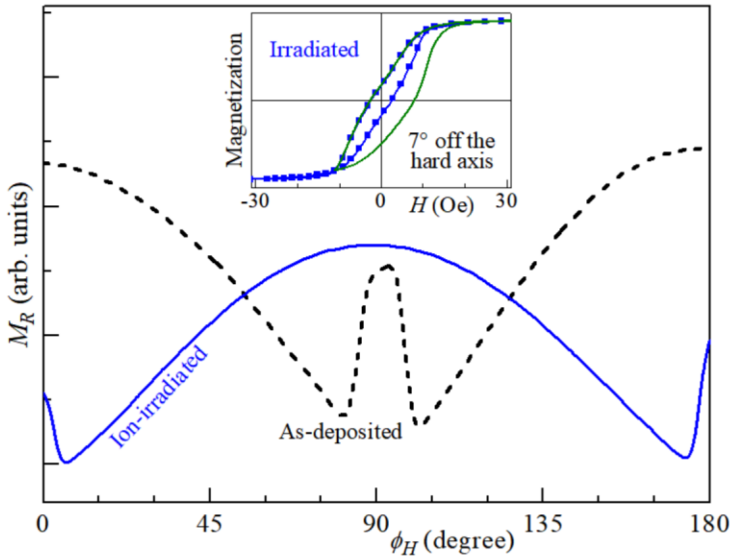
A number of polycrystalline materials feature a rather distinct characteristic–sharp peaks in the angular variations of their major-loops' remanent magnetization (M_R) and coercivity, centered 90° off the easy-axis position, see, e.g., Ref. [1]. Recently, we reported a striking phenomenon in Co, Fe and Ni films showing hard-axis collapse [2]–recoil magnetization branches that lie way outside the major loop, referred to as a recoil-curve overshoot (RCO), see the inset of the figure below.



M_R angular variations of both as-grown and Ne^+-irradiated (70 keV, fluence of 1×10^{15} ions/cm^2) 10-nm-thick Co films magnetron-sputtered on Si/Ta(18 nm). The inset shows a major (symbols) and a recoil magnetization loops of the irradiated film obtained for in-plane magnetic field applied 83° away from the (also in-plane) ion-irradiation-induced easy axis.

In the present work pieces of a magnetron-sputtered on Si/Ta(18 nm) 10-nm-thick Co film presenting RCO were subjected to either He^+ or Ne^+ irradiation in a vacuum at different fluences in the presence of an in-plane magnetic field of 3.5 kOe, applied 90° off the original easy-axis direction. While samples characterized after either 20 keV or 70 keV irradiations using fluences of 1×10^{14} ions/cm^2 did not present appreciable changes in their magnetic properties, the 70 keV Ne^+ irradiation using a fluence of 1×10^{15} ions/cm^2 resulted in a film with easy-magnetization direction parallel to that of the magnetic field applied during the ion bombardment. Importantly, a significant RCO is observed after irradiation as well, as exemplified in the figure above. Here we will point out the probable sources supplying energy for spin rearrangement and leading to easy-axis modifications of ion-irradiated films. Our results may shed light on the origin of the puzzling RCO phenomenon–while the model of pairs of exchange-coupled grains with misaligned anisotropy axes is able to reproduce the key features of systems presenting hard-axis collapse, the latter could alternatively be associated, e.g., with a domain splitting perpendicular to the hard axis during demagnetization [3].

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[1] O. Idigoras et al. J. Appl. Phys. 115 (2014) 083912
[2] J. Geshev et al. Phys. Rev. B 104 (2021) 054436
[3] J. Hamrle et al., J. Appl. Phys. 100 (2006) 103904