# Defects induced by ion collisions to control thermal hysteresis in magnetocaloric thin films


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**Synopsis** By varying different irradiation conditions, we investigate the reduction of the thermal hysteresis in magnetocaloric thin films induced by impact of slow ions. This suppression looks connected to the total deposited energy by the ions and not to the number of implanted ions. This hypothesis is reinforced by magnetic-force microscope measurements that display local changes induced by clusters of irradiation defects.


Magnetic materials with giant magnetocaloric effect are promising for application in magnetic refrigeration. But they all exhibit a first-order phase transition and suffer from a large thermal hysteresis, which reduces significantly the efficiency of the refrigeration cycle. Several studies aimed at getting rid of the thermal hysteresis but it was to the detriment of the other magnetic properties, inducing for instance a collapse of the refrigerant power [1, 2].

In previous studies, using heavy ion impact at low energy, we demonstrated that the thermal hysteresis of the MnAs thin film, a material with giant magnetocaloric properties, can be entirely suppressed whereas other structural and magnetic properties are barely affected [3]. This modification is found to be stable [4], but the mechanisms at the origin of this thermal hysteresis suppression were not completely understood.

To disentangle the ion implantation effects from the ion collision-induced defects, we have investigated the role of different parameters like the projectile mass and energy, and the ion fluence. As displayed in Figure 1, the thermal hysteresis reduction is proportional to the deposited energy in the film, and not to the implanted ion number (not shown). The deposited energy is in fact related to the total number of collisions, which depends on the ion mass and kinetic energy. These collisions induce new defects that seem to locally favor the presence out-of-equilibrium phase regions [5] as recently demonstrated by magnetic-force microscopy. These regions act as seeds during the phase transition producing the reduction of the thermal hysteresis, similarly to recent investigation on phase nucleation by nanoindentation of thin films [6].

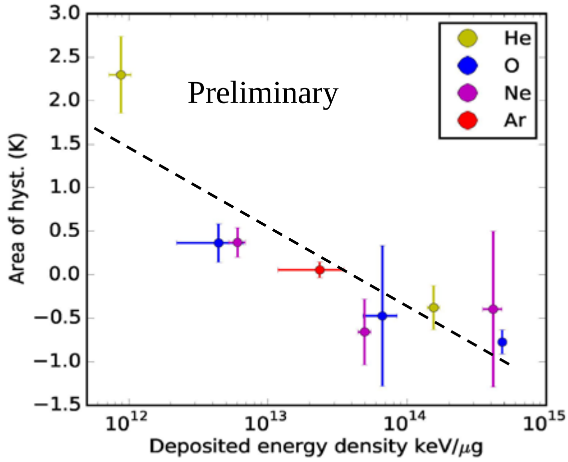


**Figure 1.** Normalized hysteresis area of MnAs thin films submitted to irradiation of different ions at various fluences. Note the reversion of the hysteresis when deposited energy density increases.


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## References


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