



**HAL**  
open science

## Impacts of highly charged ions as seeds in a magneto-structural phase transition of magnetocaloric thin films

S Cervera, Martino Trassinelli, Massimiliano Marangolo, L Bernard-Carlsson, Mahmoud Eddrief, Victor H. Etgens, V Gafton, S Hidki, Emmanuelle Lacaze, Emily Lamour, et al.

### ► To cite this version:

S Cervera, Martino Trassinelli, Massimiliano Marangolo, L Bernard-Carlsson, Mahmoud Eddrief, et al.. Impacts of highly charged ions as seeds in a magneto-structural phase transition of magnetocaloric thin films. *Journal of Physics: Conference Series*, 2015, 635 (3), pp.032021. 10.1088/1742-6596/635/3/032021 . hal-01265737

**HAL Id: hal-01265737**

<https://hal.sorbonne-universite.fr/hal-01265737v1>

Submitted on 2 Feb 2016

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution 4.0 International License

## Impacts of highly charged ions as seeds in a magneto-structural phase transition of magnetocaloric thin films

This content has been downloaded from IOPscience. Please scroll down to see the full text.

2015 J. Phys.: Conf. Ser. 635 032021

(<http://iopscience.iop.org/1742-6596/635/3/032021>)

View [the table of contents for this issue](#), or go to the [journal homepage](#) for more

Download details:

IP Address: 134.157.80.136

This content was downloaded on 01/02/2016 at 13:42

Please note that [terms and conditions apply](#).

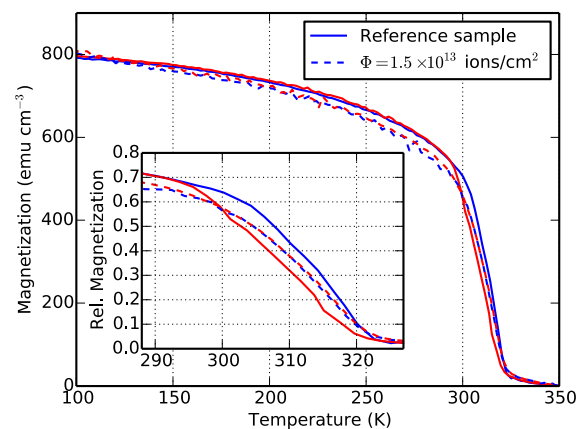
## Impacts of highly charged ions as seeds in a magneto-structural phase transition of magnetocaloric thin films

S. Cervera<sup>1</sup>, M. Trassinelli<sup>2</sup>, M. Marangolo, L. Bernard-Carlsson, M. Eddrief, V.H. Etgens, V. Gafton, S. Hidki, E. Lacaze, E. Lamour, C. Prigent, J.-P. Rozet, S. Steydli, Y. Zheng and D. Vernhet

CNRS, UMR 7588, Institut des NanoSciences de Paris (INSP), 4 Place Jussieu, 75005 Paris, France  
Sorbonne Universités, UPMC Univ. Paris 06, INSP, UMR 7588, F-75005 Paris, France,

**Synopsis** Investigation on modifications of structural and magnetic properties of magnetocaloric thin films induced by slow highly charged ions bombardment under well-controlled conditions is presented. The ions induce defects/constraints that facilitate nucleation of one phase with respect to the other in the first-order magneto-structural MnAs, with a consequent suppression of thermal hysteresis, but without any significant perturbation on the other structural and magnetic properties.

Modifications of material properties by ion impact, and in particular changes in magnetic features, have been extensively studied in the last decades. Nevertheless, previous studies on the effect of ion impact were focused mostly on materials exhibiting a second-order magnetic transition and with singly charged ions whilst, here, we investigate thin film presenting a first-order magneto-structural transition, namely MnAs, irradiated with slow highly charged ions, i.e. 90 keV ( $v=0.4$  a.u.)  $\text{Ne}^{9+}$  [1, 2]. Indeed, MnAs is one of the most promising candidates for developing magnetic refrigeration since it exhibits giant magnetocaloric effect (GMCE) associated to its phase transition close to room temperature (at  $T_c=40^\circ$ ). Up to now, the practical use of GMCE materials for real refrigerator systems is blocked by the presence of a large thermal hysteresis in the magnetization cycle, which is typical of first-order transition materials (fig. 1, solid lines). Differently from other technics applied previously to reduce the thermal hysteresis (like doping, external strains, ...) [3–5], ion collisions induce defects that act as seeds for the nucleation of one phase with the other during the transition. Consequently, the thermal hysteresis is entirely suppressed (fig. 1, dashed lines) whereas other structural and magnetic properties are only slightly affected. In particular, the large refrigeration power of MnAs thin films related to GMCE is preserved. At present, we extend our investigations using different collision conditions and other samples that are relevant for the magnetic refrigeration (FeRh, compounds based on  $\text{Fe}_2\text{P}$ , etc.). The goal is to provide new insights on the fundamental processes that play a major role in the suppression of the thermal hysteresis in order to get a full understanding on this effect.



**Figure 1.** (color online) Magnetization as a function of temperature for the reference (solid lines) and for the irradiated samples (dashed lines). Data obtained by a temperature increase (from colder temperatures) and decrease (from hotter temperatures) are presented in blue and red, respectively.

This work was partially supported by French state funds managed by the ANR within the Investissements d'Avenir programme under reference ANR-11-IDEX-0004-02, and more specifically within the framework of the Cluster of Excellence MATISSE led by Sorbonne Universités.

### References

- [1] M. Trassinelli, M. Marangolo, M. Eddrief *et al.*, Appl. Phys. Lett. **104**, 081906 (2014)
- [2] M. Trassinelli, V.E. Gafton, M. Eddrief *et al.*, Nucl. Instrum. Meth. B, **317**, 154 (2013)
- [3] B.G. Shen, J.R. Sun, F.X. Hu, H.W. Zhang, and Z.H. Cheng, Adv. Mater. **21**, 4545-4564 (2009)
- [4] J. Liu, T. Gottschall, K.P. Skokov, J.D. Moore, and O. Gutfleisch, Nature Mater. **11**, 620-626 (2012)
- [5] X. Moya, L.E. Hueso, F. Maccherozzi *et al.*, Nature Mater. **12**, 52-58 (2013)

<sup>1</sup>E-mail: [sophie.cervera@insp.jussieu.fr](mailto:sophie.cervera@insp.jussieu.fr)

<sup>2</sup>E-mail: [martino.trassinelli@insp.jussieu.fr](mailto:martino.trassinelli@insp.jussieu.fr)