Cristallite size tuning on magnetocaloric effect of ball milled $HoAl_2$

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The magnetocaloric effect (MCE) is the basis for alternative, environment-friendly new refrigeration technologies. It is an intrinsic property of all magnetic materials, occurring as a consequence of the coupling among external applied field and the magnetic sub-lattice. [1] In this study, we report on the synthesis, microstructural and magnetic characterization of mechanically milled $HoAl_2$ compound. The samples were investigated by using x-ray diffraction, scanning electron microscopy (SEM) and magnetization measurements. $HoAl_2$ polycrystalline sample were submitted to a milling process using high energy ball mill in order to produce metallic nanoparticles. The bulk sample show single phase with cubic $MgCu_2$- type structure. The lattice parameter was not significant changed by milling process up to 20 h of milling time. On the other hand, the crystallite size is strongly reduced reaching 28 nm for 20 h sample. Magnetic measurement show ferromagnetic phase transition around 32 K for bulk and all milled samples. A contribution related with spin reorientation is also observed below 20K, which becomes more pronounced as milling time increase. The magnetization of saturation reduces from 8.4 (bulk sample) to 6.2 μ_B/u.f. (20 h sample), due to the weakening of long-range magnetic ordering caused by size effects. The mechanical milling reduces the maximum values of magnetic entropy change ($-DS_M^{max}$) from 30 J/kgK (bulk sample) to 15 J/kgK (20 h milled sample). A significant broadening in the $-DS_M$ peak profile is observed as the milling time increase, which enhance in the full width half maximum (δT_{FWHM}) of entropy change peak. High values of δT_{FWHM} are associated with a large operation temperature range of magnetic refrigerator prototypes making the milled $HoAl_2$ interesting for magnetic refrigeration purposes.

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References:

[1] V. K. Pecharsky *et al.*, Phys. Rev. B 64, 144406 (2001).