Magneto-caloric effect of $Gd_{0.60}Mn_{0.40}$

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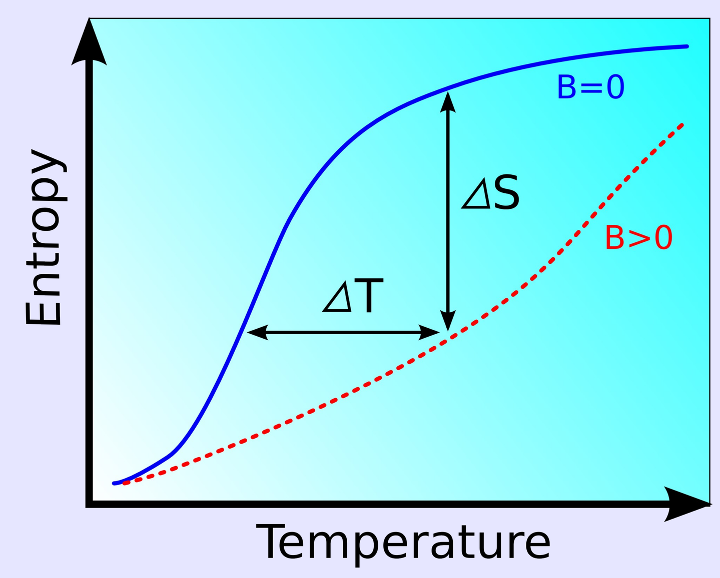
INTRODUCTION

Our research group accomplished in frame of the program '*Cesta k Vědě*' at the Physical Faculty of Charles University in Prague project 'Research of new magneto-caloric materials' . We prepared sample $Gd_{0.60}Mn_{0.40}$ and for discovering properties our team used several measuring methods as X-ray diffraction, direct and MPSM (magnetic property system measurement) method.

WHAT IS MCE ??

Magneto-caloric effect was discovered by Emil Warburg in 1881. It is isothermal change of entropy of the sample or adiabatic change of temperature when varying magnetic field.

In the future this effect will might fully replace coolants as are hydro-fluorocarbons which make greenhouse effect more than dioxide carbon. In 1926 Debye and Giauque presented the concept of the adiabatic demagnetization, independently on each other, with paramagnetic salts and reached the temperature below the 1 K.



Graph of dependence entropy on temperature. Blue curve is without external magnetic field and red is with. ΔT arrow is represents adiabatic change of temperature. ΔS arrow represents entropy change of magnetic material.

EXPERIMENTAL DETAILS

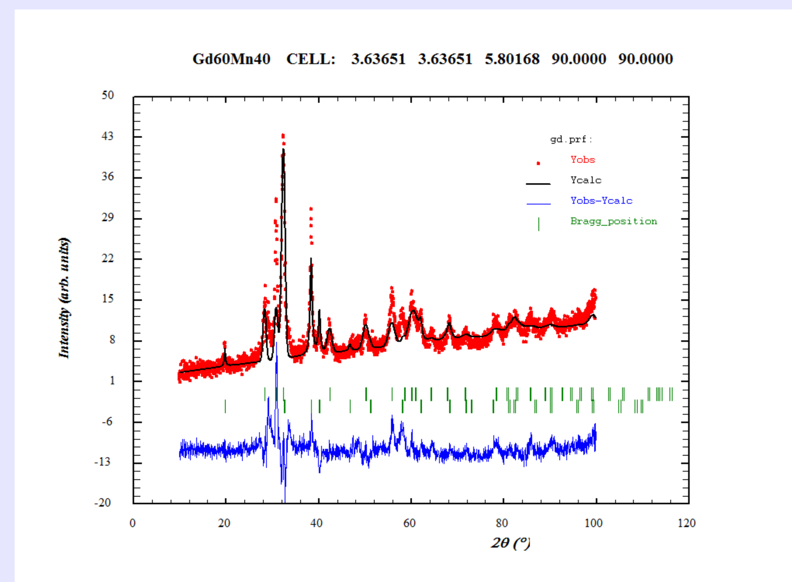
The $Gd_{0.60}Mn_{0.40}$ sample was prepared by arc-melting of stoichiometric mixture of pure element (3N for Gd and Mn) in ultra high-purity Ar atmosphere. The sample was remelted several times. The structure of the sample was checked by the x-ray powder diffraction with Cu Kα radiation.

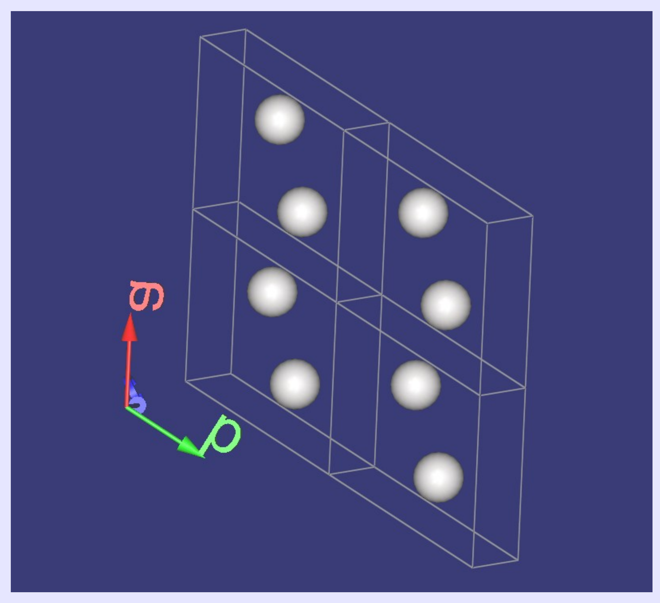
The temperature dependence of the sample magnetisation was measured on MPMS measurement system from Quantum Design. The transition temperature of the sample was determined from this dependence as the temperature where the maximum of the first derivative occurred. The entropy change of the sample was determined from the magnetisation isotherms measured in a wide temperature range from 265 to 305 K according to equation derived from the Maxwell relation.

The direct measurement of the sample temperature change was performed on simple cryostat consists of a container with liquid nitrogen and a sample holder. Temperature of the holder is controlled by a heater in the temperature range from 450 K down to 80 K. The magnetic field is produced by superconducting magnet with maximal field of 4.7 T.

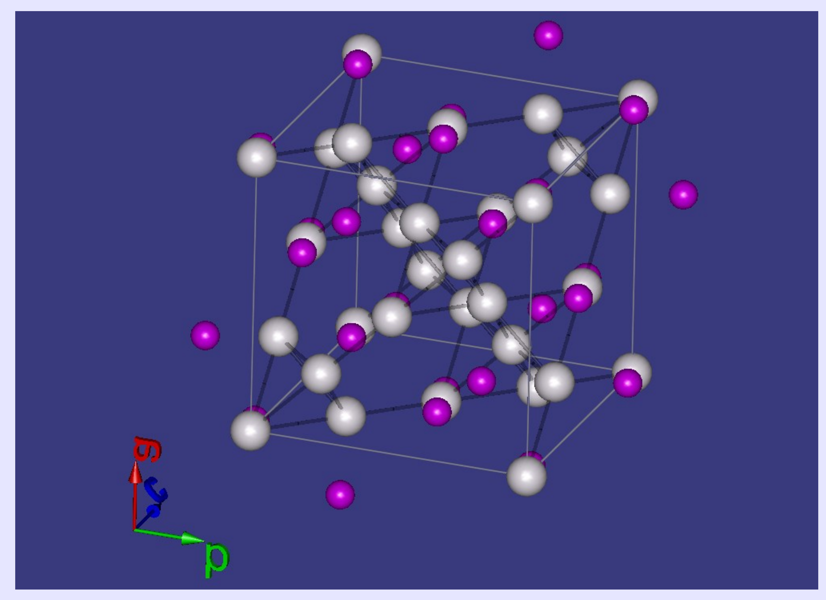
RESULTS

We found from diffraction record that alloy $Gd_{0.60}Mn_{0.40}$ is composed from two phases. First is Gd phase with hexagonal structure and the second is $GdMn_2$ phase which contains cubical structure.



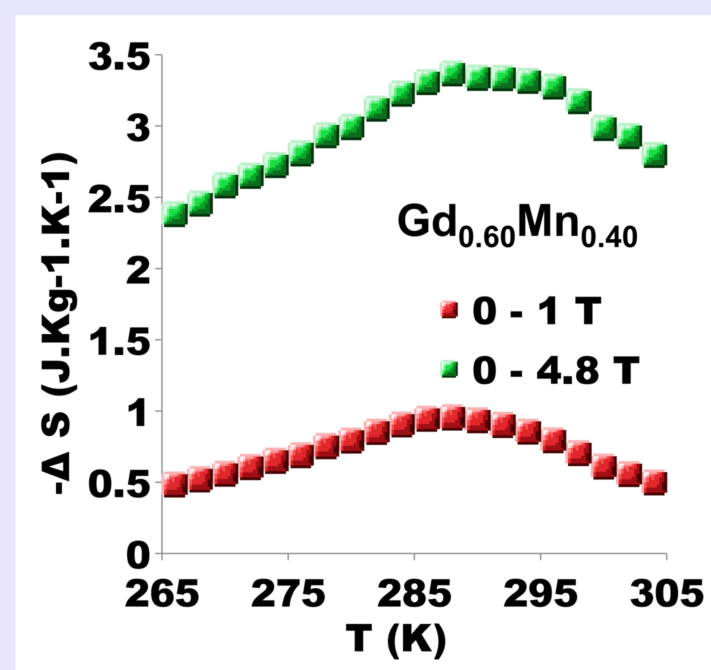


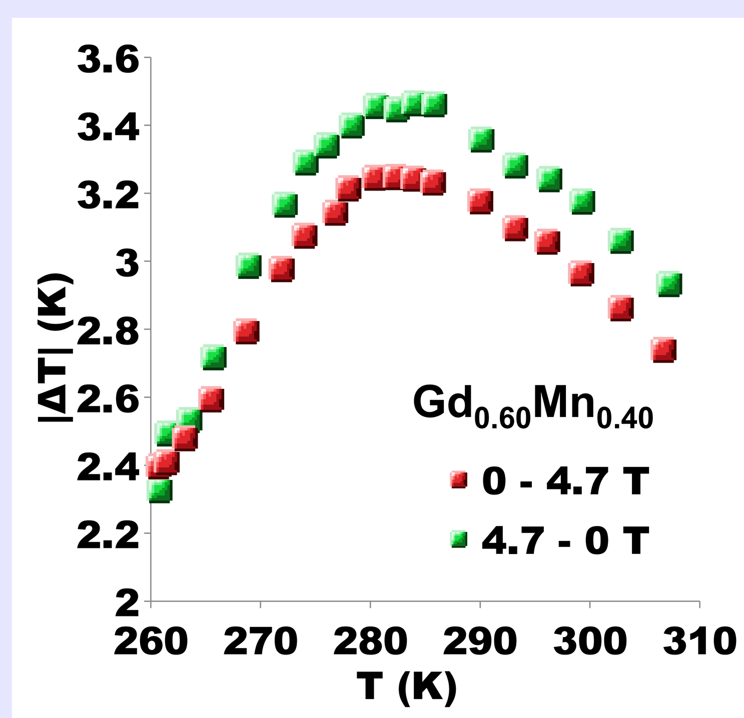
Hexagonal Gd phase



Cubical $GdMn_2$ phase

From indirect measurement of magnetization we get dependence of entropy change of the sample on external temperature. From figure it can be seen that maximum of curves is at temperature 288 K. For 0 – 1 T field change is 0.95 $J.Kg^{-1}.K^{-1}$ and for 0 – 4.8 T is 3.37 $J.Kg^{-1}.K^{-1}$.





From direct measurement we created figure of dependence of temperature change on external temperature and we found from this that maximum is at temperature 284 K. For 0 – 4.7 T field change is maximum 3.25 K and for 4.7 – 0 T field change is 3.45 K.

CONCLUSIONS

The magneto-caloric properties of $Gd_{0.60}Mn_{0.40}$ were measured. The maximum of the MCE corresponds with transition temperature T_C. The direct measurement of the adiabatic temperature change was performed. The obtained result shows decrease of the MCE from values obtained on pure Gd. Despite this the $Gd_{0.60}Mn_{0.40}$ alloy is still a good candidate for application in room-temperature refrigeration.

ACKNOWLEDGMENT

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