Magnetic properties and magnetocaloric effect in the $Sc_{0.4}Ti_{0.6}Fe_2$ Laves phase compound

V. Anière,[1] K. Synoradzki,[1] T. J. Bednarchuk,[2] and T. Toliński[1]

[1] *Institute of Molecular Physics, Polish Academy of Sciences, Poznań, Poland*
[2] *Institute of Low Temperature and Structure Research,*
Polish Academy of Sciences, Wrocław, Poland

The exploration of Laves phase intermetallic compounds has remained an important focal point in condensed matter physics due to a complex interplay between crystal structure and itinerant electron magnetism. Magnetic state dependence of the unit cell volume was established in Laves phase $Sc_{1-x}Ti_xFe_2$ samples, with a possible transition from the positive thermal expansion of the parent compounds to the negative thermal expansion (NTE) in $Sc_{0.4}Ti_{0.6}Fe_2$. This composition has also been shown to exhibit a transition between two distinct ferromagnetic (FM) states [1-2] at a critical temperature T_C. In this work, polycrystalline samples of $Sc_{0.4}Ti_{0.6}Fe_2$ were produced by arc-melting. X-ray diffraction measurements confirmed that the compound crystallizes in a hexagonal ($C14$, $MgZn_2$-type) structure (space group $P6_3/mmc$). Magnetization measurements at applied magnetic fields of 0.1 T and in the temperature range 2-380 K show a paramagnetic (PM) to FM transition around $T_{C1} = 370$ K, as well as the characteristic FM-FM transition around $T_{C2} = 120$ K. The material displays soft ferromagnetic properties across the entire temperature range, as no hysteresis loops were observed in the tested samples. Based on isothermal magnetization measurements, the magnetocaloric effect (MCE) was determined, showing a value of magnetic entropy change $|\Delta S_M| = 1.65 \pm 0.02\ \mathrm{J\,kg^{-1}\,K^{-1}}$ at 152.0 ± 0.5 K for a magnetic field change of 5 T. The approximate relative cooling power (RCP) obtained is of 160 $\mathrm{J\,kg^{-1}}$. An additional maximum in temperature dependence of ΔS_M can be observed at $T = 380$ K, providing the possibility of an extended operating temperature range for this compound. Although the overall MCE magnitude is modest, magnetocaloric properties can be optimized by chemical substitution.

References:

[1] Y. Nishihara, Y. Yamaguchi, Journal of the Physical Society of Japan 55.3 (1986) 920-935
[2] Y. Song et al., Materials Horizons 7.1 (2020) 275-281

Funded by the National Science Centre, Poland under the OPUS call in the Weave programme 2023/51/I/ST11/02562.