

Near-Room-Temperature Magnetocaloric Effect in Fe-Based Laves Phases

Valentin Anière^{*1}, Tamara J. Bednarchuk², Michał Matczak¹, Catalina Salazar Mejía³,
Tomasz Toliński¹, Karol Synoradzki^{1,*}

¹Institute of Molecular Physics, Polish Academy of Sciences, Poznań, Poland

²Institute of Low Temperature and Structure Research, Polish Academy of Sciences,
Wrocław, Poland

³Hochfeld-Magnetlabor Dresden (HLD-EMFL), Helmholtz-Zentrum, Dresden, Germany

Fe-based Laves phase intermetallics are of significant interest due to their versatile magnetic properties and potential applications in magnetic refrigeration. This study investigates the structural, magnetic, and magnetocaloric properties of polycrystalline $\text{Sc}_{1-x}\text{Ti}_x\text{Fe}_2$ Laves phase compounds, aiming to identify materials with high application potential for magnetic cooling near room temperature. The investigated compounds crystallize in the hexagonal C14 structure (space group $P6_3/mmc$), where Fe atoms occupy the $2a$ and $6h$ Wyckoff positions.

Experimental results reveal that substituting Ti for Sc significantly modifies the magnetic structure, transition temperature, and the magnitudes of both the magnetic entropy change (ΔS_m) and the adiabatic temperature change (ΔT_{ad}), showing a pronounced sensitivity to compositional changes near $x = 0.8$. Among the tested series, the $\text{Sc}_{0.2}\text{Ti}_{0.8}\text{Fe}_2$ sample exhibits complex magnetic behavior, featuring a paramagnetic-to-ferromagnetic (PM–FM) transition close to room temperature. At lower applied magnetic fields, additional transitions occur, including a FM-to-FM transition around 160 K and a FM-to-antiferromagnetic-like transition near 70 K.

Under a magnetic field change of $\Delta\mu_0H = 5$ T, this composition yields a ΔS_m of $1.3 \text{ J kg}^{-1}\text{K}^{-1}$ at 312 K and a relative cooling power (RCP) of 203 J kg^{-1} . Direct measurements of ΔT_{ad} in pulsed magnetic fields reached a maximum of 0.7 K at 300 K for $\Delta\mu_0H = 5$ T. Although these magnetocaloric parameters leave room for further optimization, the findings demonstrate that precise compositional adjustments allow for effective tuning of both the transition temperature and the magnetocaloric response, confirming that the $\text{Sc}_{1-x}\text{Ti}_x\text{Fe}_2$ system holds strong promise for energy-efficient cooling technologies.

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* karol.synoradzki@ifmpan.edu.pl