Development of metamagnetic shape memory alloy powders for 3D printing

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Solid-state cooling has emerged as a promising alternative to conventional vapor-compression refrigeration due to its higher energy efficiency and lower environmental impact. This technology is based on caloric effects induced in materials subjected to external stimuli such as mechanical stress, hydrostatic pressure, magnetic fields, or electric fields. Among the most attractive caloric materials are metamagnetic shape memory alloys (MSMAs), which exhibit multifunctional responses to thermal, mechanical, and magnetic stimuli owing to a martensitic transformation (MT) between two crystallographic phases with distinct magnetic states. This magnetostructural transition is associated with a large entropy change (ΔS), resulting in a giant magnetocaloric effect (MCE) comparable to that of benchmark materials such as Gd–Si–Ge, La–Fe–Si, and manganite compounds. However, the widely investigated Ni-(Co)-Mn-(In,Sb,Ga) alloys are intrinsically brittle, exhibit poor mechanical stability, and suffer degradation under cyclic operation. These limitations hinder their implementation in refrigeration technologies requiring complex shape-memory architectures with high specific surface area and long-term durability. To address these challenges, polymer-based composites functionalized with MSMA powders and compatible with additive manufacturing techniques have emerged as a promising strategy for the fabrication of multifunctional magnetocaloric systems. In this work, the production of Ni–Mn–Ga–Cu powders and their processing into printable polymer composites are presented.