Towards Rare Earth-Lean $SmFe_{12}$-based Magnets: Challenges and Future Prospects

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Permanent magnets are crucially important for green technologies, where demand increases constantly to achieve net zero greenhouse gas emissions. Currently, high-performance Nd-Fe-B magnets are widely used for this purpose. However, these magnets require heavy rare earth elements like dysprosium and terbium to operate the magnets at temperatures of over 100°C. These elements are not only scarce and costly but also pose environmental and supply chain risks. Recently, there has been renewed interest in $SmFe_{12}$-based compounds as potential candidates for high-performance magnets. These compounds possess the highest Fe content among the 4f-3d magnets and exhibit superior intrinsic magnetic properties, such as saturation magnetization and anisotropy field, compared to $Nd_2Fe_{14}B$ [1,2].

Despite these advantages, their practical application is hindered by phase instability and challenges in achieving the optimal microstructure. In this talk, we will discuss these obstacles and strategies to overcome them, aiming to accelerate the development of SmFe12-based magnets as the next generation of high-performance magnets. We will highlight the roles of different phase-stabilizing elements and the effects of processing conditions on phase formation/decomposition and microstructure, especially twin formation [3-5]. Finally, we will explore how a data-driven combinatorial approach can significantly expand our limited thermodynamic understanding of Sm-Fe-M systems, which is especially crucial for achieving an optimal equilibrium between hard magnetic and non-magnetic low-melting-point phases.

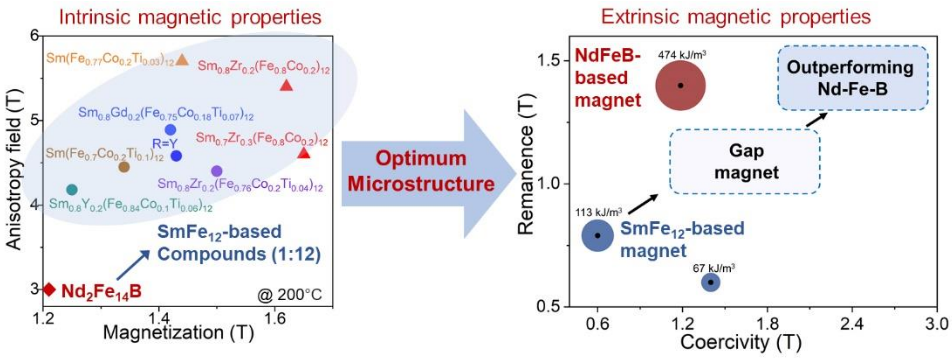

Fig. 1. Transforming the intrinsic magnetic properties to extrinsic ones.

Reference

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