A search for Novel Alloys for Permanent Magnet Industry

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Permanent magnets are vital components in an enormous number of domestic and industrial devices. They are particularly crucial within the rapidly-developing renewable energy sector, where the motors for electric vehicles and the generators in wind turbines require strong magnets with the ability to operate at temperatures well over 100°C. Nd-Fe-B based permanent magnets show the largest maximum energy product among all types of permanent magnets, thus it is the material of choice for energy conversion and mobility applications. Currently, rare earth elements neodymium and dysprosium are scarce ~~on~~ in the world and there is a need for a new magnet with little or no heavy rare earth to fill the gap magnet between ferrite and Nd-Fe-B (Fig 1(a)), to be used for intermediate energy applications or replace the champion Nd-Fe-B magnet for high energy applications.

In this talk, I will discuss on development of Y-Co-Fe based novel permanent magnet that could fill the gap between sintered ferrite and rare earth magnets (Fig. 1(b)) with a maximum energy product of 140 kJ/m^3 [1,2]. Moreover, invention of new magnetic materials is tested based on first principle supercomputer-generated recipes. I demonstrated experimentally the validation of the high-throughput computational screening calculation for Heusler alloys where first time two new magnets have been discovered due to the collaborative work of theory and experiment [3]. Recently, we discovered that $Sm(Fe_{0.8}Co_{0.2})_{11}Ti_1$ and $(Sm_{0.8}Zr_{0.2})(Fe_{0.8}Co_{0.2})_{11.5}Ti_{0.5}$ with $ThMn_{12}$ structure, show superior intrinsic magnetic properties than that of $Nd_2Fe_{14}B$ phase for elevated temperature applications [4]. The sole effect of Zr on the intrinsic magnetic properties cannot be investigated directly from bulk samples, since $ThMn_{12}$-type structure without Ti cannot be stabilized in the absence of Zr. In order to unveil the sole effect of Zr, we also develope~~d~~ highly textured $(Sm_{1-x}Zr_x)(Fe_{0.8}Co_{0.2})_{12}$ films [5]. In a conclusion, the current progress towards a novel magnet will be discussed widely in this talk.

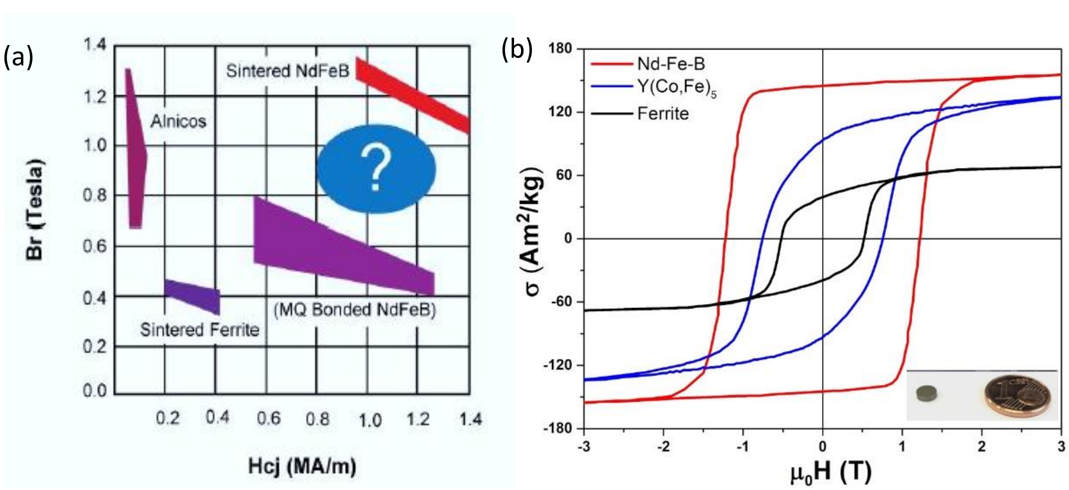

Fig. 1 (a) Permeant magnetic materials which are available in the industry (b) Hysteresis curves of low- (ferrite), medium- (Y-Co-Fe) and high-performance (Nd-Fe-B) magnet.

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[2] P. Tozman et al. AIP Adv. 6, 056016, (2016).
[3] S. Sanvito et al. Science Advances, e1602241, 4, (2017)].
[4] P. Tozman et al., Acta Mater., 153, 354-363 (2018)
[5] P. Tozman et al., in press, (2019)