Sustainable Design of New Permanent magnets

Davide Peddis

Università degli Studi di Genova, Dipartimento di Chimica e Chimica Industriale, nM2-Lab, Via Dodecaneso 31, 1-16146 Genova, Italy
CNR, Istituto di Struttura della Materia, nM2-Lab, Monterotondo Scalo (Roma), 00015, Italy

The increasing efforts towards a greener and more sustainable future have significantly enhanced the demand for rare-earth-based permanent magnets (RE-PMs), which are key components of environmentally friendly energy technologies such as hybrid and electric vehicles and wind turbines [1]. To respond to this growing demand and to mitigate the strong dependence on Chinese production and processing of rare-earth (RE) elements [2], intense computational and experimental activities have recently focused on reducing the demand and use of REEs. These efforts include the recycling and reuse of End-of-Life (EoL) magnets, the optimization of existing materials, and the development of new hard magnetic phases.
Within this framework, the Nanostructured Magnetic Materials Laboratory (www.nm2lab.com) proposes specific strategies to implement a sustainable design of new permanent magnets. Among the recycling approaches, particular attention is devoted to the magnet-to-magnet strategy, in which EoL magnets are mechanically processed into powders, dispersed in suitable polymers and reused to fabricate new magnets [3]. This approach minimizes waste and resource depletion while significantly reducing the environmental footprint associated with chemical processing. In parallel, rare-earth-free hard/soft exchange-coupled nanocomposite powders based on $BaFe_{12}O_{19}$ hexaferrites as the hard phase and $CoFe_2O_4$ spinels as the softer phase are being developed to produce mid-range permanent magnets bridging the gap between hexaferrites and RE-PMs [4,5]. Finally, considerable efforts are devoted to the synthesis of the $L1_0$-FeNi alloy, a promising candidate for next-generation rare-earth-free permanent magnets, using a scalable and sustainable chemical route that enables the formation of partially ordered nanoparticles with competitive magnetic properties [6].

References:
[1] O. Gutfleisch et al., Adv. Mater. 23 821(2011).
[2] J. M. D. Coey, Engineering 6 119 (2020).
[3] A. G. Haghighat, et al.. RSC Sustain. (2025)
[4] P. Maltoni, et al., J. Phy. Chem. C, 125, 10, 5927–5936, (2021)
[5] P. Maltoni, J. Appl. Phys. D 54 124004, pp.10 (2021)
[6]A. Capobianchi and G. Varvaro, Patent Application Filed #102022000024852 (2022).