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TITLE: Discovery of a new high-T_c ferromagnet in Fe-rich Ce – Fe – Zr alloys.

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ABSTRACT BODY:

Abstract Body: Ce – Fe ferromagnetic phases are very economical, considering abundance and low cost of both, Ce, and Fe. They represent an alternative material for RE-permanent magnets containing critical, thus expensive, RE like Nd, Sm and Dy, as well as nearly critical Co [1,2]. Introducing Fe instead of Co is advantageous both, from the material cost prospective, as well as from the standpoint of generally higher saturation magnetizations, because of higher magnetic moment of Fe. However, there is no Ce – Fe permanent magnet yet known. One reason is the lack of Ce – Fe compounds; another is that the existing Ce – Fe binaries do not exhibit ferromagnetism above the room temperature. We have discovered a new ferromagnetic compound, rhombohedral (Ce,Zr)Fe_3 phase ($PuNi_3$-type, *R*-3*m*). In contrast to all known Ce – Fe binary compounds, which are not ferromagnetic at room temperature, the new phase is strongly ferromagnetic with Curie point 550 K (see Figure below). The saturation magnetization of the system at room temperature reaches 9.3 kG at 3T external field. These are intrinsic indicators of practical 20 – 25 MGOe permanent magnet. The material contains no critical elements and allows utilization of abundant domestic Ce (50 % of MP ore). All the above factors place it well along the target to win industry adoption for substitutes of the rare earth magnets.

References: [1] K. Strnat, G. Hoffer, J. Olson, W. Ostertag, and J. J. Becker, A Family of New Cobalt-Base Permanent Magnet Materials, J. Appl. Phys. 38 (1967) 1001.
[2] Galler, S. Ener, F. Maccari, I. Dirba, K. P. Skokov, O. Gutfleisch, S. Biermann, and L. V. Pourovskii, intrinsically weak magnetic anisotropy of cerium in potential hard-magnetic intermetallics, arXiv:2006.01792.

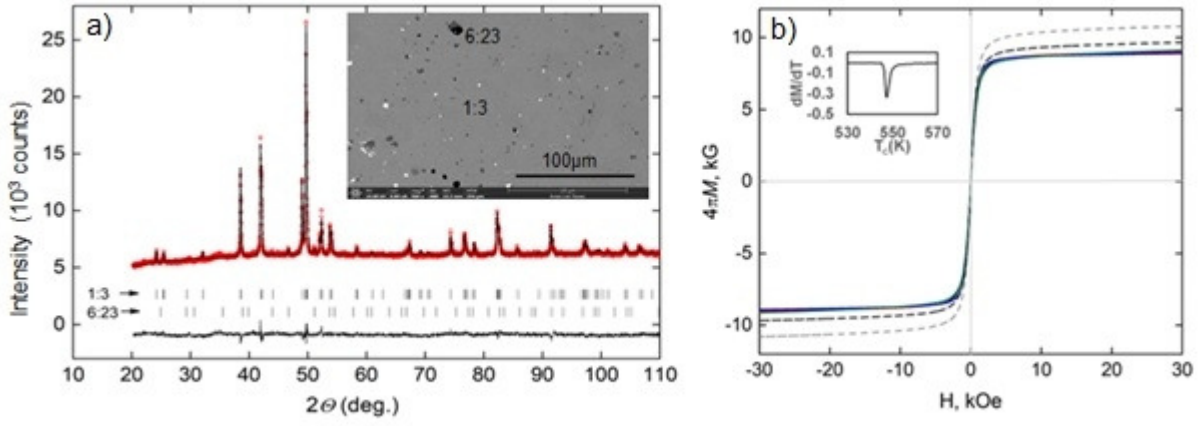

Fig: a) Rietveld refinement of the X-ray powder pattern of the heat-treated (Ce,Zr)Fe_3 confirming the hexagonal $PuNi_3$-type crystal structure (Inset: SEM backscattered electrons image of the same sample showing > 90% single-phase material at Ce:Zr ~ 2/3, b) M/H curves of heat-treated samples along the 75 at.% Fe (Inset: Curie point at 550 K of the Ce:Zr ~ 2/3 sample)