Nanocrystalline Magnetic Alloys

In conventional magnetic alloys (e.g.,electrical steels), used for transformer core applications, the efficiency improves as the crystallites making up the material are increased in size. Opposite to this conventional approach, recent research has shown that producing magnets with crystallite sizes below 15 nm can have much better energy efficiency than conventional alloys. One of the great benefits of this new class of alloys is their excellent performance at switching frequencies that exceed conventional materials, resulting in the ability to reduce the size of magnetic components using this technology. For this reason, the Navy has supported innovative materials development of nanocrystalline magnetic alloys with a focus on size and weight reduction for ship power systems.

Despite the enhanced magnetic properties derived from nanoscale domains, these materials can be notoriously brittle. The loss of ductility can limit the application or induce premature failure. Researchers at the Naval Research Laboratory have developed new nanocrystalline alloys, rich in cobalt, that significantly reduce the embrittlement over conventional iron-based magnetic alloys. Thin ribbons of this magnetic material were spun at high temperature to thicknesses less than half the diameter of a human hair. These ribbons were then bent and compressed to assess their fracture strength, which was twice that of the conventional alloy.

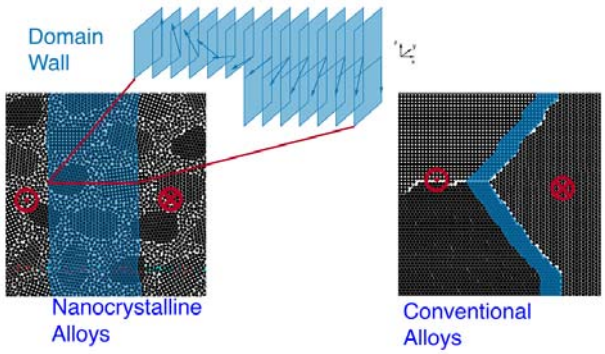

Figure: Magnetic domain wall mobility is an important parameter for magnetic material performance. Magnetic domain wall motion is restricted in conventional magnetic alloys due to the interfaces between crystallites, causing the poles of the magnet to switch directions inefficiently. Nanocrystalline alloys have crystallites that are so small that the magnetic domain walls are not seen as impediments to motion.

T. M. Heil, K. J. Wahl, A. C. Lewis, J. D. Mattison, and M. A. Willard, "Nanocrystalline Soft Magnetic Alloys with High Relative Strain at Fracture," *Applied Physics Letters* **90** (2007) 212508.

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