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Improving superconductors, one defect at a time

Superconductors hold the promise of dissipation-less electrical currents. In reality superconductors are limited by their critical temperature (superconductors need to be cooled down), and the amount of current they pass known at critical current. The former is an intrinsic characteristic of the material, but the latter can be increased orders of magnitude by microstructure modification. Microscopically, dissipation in superconductors is caused by the movement of vortices once the critical current has been reached, however vortex movement can be arrested by adding pinning centers by way of material defects.   Thus studying the effect of disorder in superconductors leads to better understanding the physics of interacting elastic objects (vortices) and improving superconductors.

Nano particles have been extremely successful to enhance the critical current and increase the temperature-magnetic field region of usefulness. While using the same chemistry, the morphology, size and distribution of nanoparticles can vary wildly between different types of deposition (e.g. pulsed laser deposition or metallic organic decomposition) from small strain-free nanoparticle to highly strained self-assembled columns. Even deposition conditions can be used to tune the desired 'pinning landscape' that not only regulates the pinning (how strong vortices are held), but how easy vortices can jump out of them (vortex creep).

I will present recent studies in the two of the most promising families of superconductor, $BaFe_2As_2$ and $YBa_2Cu_3O_7$. Comparisons between different types of nanoparticles and superconductors at diverse temperature and magnetic field regimes allowed us to draw key conclusions with respect of the strength and efficiency of nanoparticles in vortex pinning and dynamics in cuprates and iron-pnictides.

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