Electron holography of high temperature superconductors

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Medium resolution electron holography is a transmission electron microscopy (TEM) technique which can be used to study magnetic and electric fields. This technique has been used by researchers to study magnetic vortex formation and migration in type-II superconductors with mixed success. The understanding of magnetic vortex migration and the pinning of vortices by microstructural defects is important as it is the principal mechanism which defines the superconductor wire's current-carrying capacity [1].

Two electron holography techniques can be used to study the magnetic vortices: off-axis or in-line electron holography. Quantitative information about magnetic and electric fields can be obtain from the off-axis technique, whereas with in-line electron holography, or coherent beam Lorentz microscopy, vortex migration can be observed. Previous work has been done by Tonomura and co-workers on YBa2Cu3O7-δ (YBCO) single crystals [2] using the 1 MeV transmission electron microscope they developed [3].

In this current project, we used in-line electron holography, with a 300 keV probe-corrected FEI Titan, to study magnetic vortices in a YBCO crystal. Many challenges have been encountered including sample inhomogeneity, geometry and preparation. In particular, the observation of magnetic vortices in-situ requires that the sample be cooled with liquid helium, presenting further experimental restraints. In this presentation, I will present the progress we have made with vortex imaging of YBCO using Lorentz microscopy with a TEM operated at 300 keV, and discuss the experimental challenges.

References

[1] X Obradors *et al*, "Growth, nanostructure and vortex pinning in superconducting $YBa_2Cu_3O_7$ thin films based on trifluoroacetate solutions", Supercond. Sci. Technol, **25** (2012) Art. No. 123001.
[2] A Tonomura, *et al*, "Observation of Structure Chain Vortices Inside Anisotropic High-T_c Superconductors", Phys. Rev. Lett, **88** (2002) Art. No 237001.
[3] T Kawasaki *et al,* "Fine crystal lattice fringes observed using a transmission electron microscope with 1 MeV coherent electron waves", Applied Physics Letters, **76** (2000) Art. No 1342.

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