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Detecting Vortices in Thin Layered Superconductor $NbSe_2$ Using Small Tunnel Junctions

When a magnetic field is applied to a type-II superconductor, magnetic flux called vortices penetrates into the superconductor in some magnetic field range. Each vortex carries flux quantum $\Phi_0 = h/2e = 2 \times 10^{-15}$ wb and vortices form a triangular lattice due to the repulsive interaction. For a thin superconducting flake with a lateral size comparable to the magnetic penetration depth (which is called mesoscopic superconductor), not only the vortex-vortex interaction but the vortex-boundary interaction affects the vortex configuration, and there appears a possibility that one can control the quantum vortex states for the application to quantum sensing and so on.

So far, we have investigated the mesoscopic vortex states in thin aluminum superconductors and succeeded in observing novel vortex states such as a giant vortex [1] and one-dimensional vortex [2], and controlling the vortex states using applied currents.[3] The vortices were detected using small tunnel junctions attached to the superconductor. In spite of the successful observation of the novel vortex states, their control was extremely difficult, mainly due to the inevitable surface roughness of the deposited superconducting films, which tends to trap the vortices.

Here, we are trying to apply our technique to layered superconductors obtained with mechanical exfoliation. Layered superconductors have ideally no surface roughness, so that we expect that the control of the vortex states is easier. Besides, some of layered superconductors are known to exhibit exotic superconducting states. Figure 1 shows an example of our samples. Several Au leads are connected to an $NbSe_2$ flake through tunnel junctions. We will show the vortex penetration and expulsion characteristics in such mesoscopic $NbSe_2$ superconductors.

References

[1] A. Kanda et al., Phys. Rev. Lett. 93 (2004) 257002.
[2] A. Kanda et al., Phys. Rev. B 76 (2007) 094519.
[3] M.V. Milosevic et al., Phys. Rev. Lett. 103 (2009) 217003.

Figures

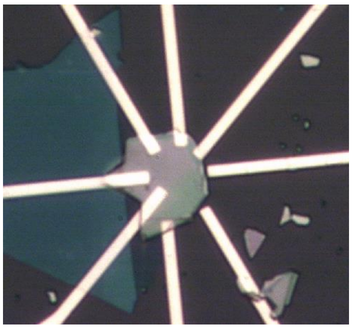

Figure 1: Optical image of an $NbSe_2$ flake with several Au leads. The width of the leads is 1 μm.