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Vortex penetration and expulsion in $NbSe_2$ mesoscopic superconductors detected by small tunnel junction method

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By using the mechanical exfoliation method developed in the graphene research, one can obtain exfoliated films with atomically flat and defect-free surfaces. Such high uniformity is advantageous for researches of physical phenomena that are easily hindered by defects or surface roughness. Here, we use exfoliated films of a layered superconductor to investigate vortices in mesoscopic superconductors.
To electrically detect vortex penetration, expulsion, and positional change in a mesoscopic superconductor, we attached a superconductor/insulator/normal metal (SIN) junction to the superconductor (small tunnel junction method). In this structure, the junction voltage under a small current is sensitive to the supercurrent underneath the junction, which is changed by the behavior of vortices. In this study, $NbSe_2$ is used as the layered superconductor, a cleaved film of MoS_2 is used as the tunnel barrier, and Cr/Au electrodes are used as the normal metal. In the sample fabrication, we first formed a stacked structure $NbSe_2/MoS_2$, and then a Cr/Au electrode was connected to the stacked structure to form a tunnel junction with area of about 1 mm^2, and a current lead was directly connected to the $NbSe_2$ flake. Finally, the sample was etched into a rectangular shape with size of ~ 4 mm^2 by reactive ion etching.
In the magnetic field dependence of the voltage of the SIN junction under a constant small biasing current, for small and increasing magnetic fields, almost periodic voltage jumps were observed, corresponding to one-by-one single vortex penetration. On the other hand, highly irregular voltage jumps were observed in other magnetic field regions. In the presentation, we will discuss these experimental results and their interpretation in detail.

Keywords: Vortex, NbSe2