

Wide-Field Magnetic Imaging of Shielding-Current-Driven Vortex Redistribution under Local Laser Heating Using Nitrogen-Vacancy Centers in Diamond

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Superconducting vortex motion can affect the performance of superconducting devices, such as superconducting nanowire single-photon detectors [1], making it important to control and visualize vortices. In our previous work, we demonstrated quantitative wide-field NV imaging of vortices [2] using perfectly aligned ensemble NV centers in diamond [3]. In this study, we applied this technique to vortex imaging in NbN thin films.

By continuously measuring the magnetic-field distribution in an NbN thin film at several temperatures a few kelvin below the superconducting transition temperature, we successfully observed changes in the vortex configuration [4]. We showed that vortex motion occurs depending on the local temperature. Furthermore, by combining local laser heating with global magnetic-field variation, we demonstrated collective vortex motion in the selectively laser-heated region. The calculated Lorentz force from the shielding current is consistent with the observed motion. The ability to induce collective vortex motion within a localized region of a superconductor and quantitatively track the resulting motion provides a useful means of investigating vortex-pinning properties in the interior of superconducting thin films, away from the film edges. Furthermore, this approach provides a proof of concept for expelling vortices from vortex-sensitive regions of superconducting devices.

[1] T. Yamashita *et al.*, Appl. Phys. Lett. **99**, 161105 (2011).

[2] S. Nishimura *et al.*, Appl. Phys. Lett. **123**, 112603 (2023).

[3] T. Tsuji *et al.*, Diam. Relat. Mater. **123**, 108840 (2022).

[4] R. Ota *et al.*, Appl. Phys. Lett. **129**, 062601 (2026).