Ultradense Tailored Vortex Pinning Arrays in Superconducting $YBa_2Cu_3O_{7-\delta}$ Thin Films Created by Focused He Ion-Beam Irradiation for Fluxonics Applications

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Supporting Information

Critical current and resistance data of a square array of vortex pinning centers fabricated by irradiation in the helium ion microscope

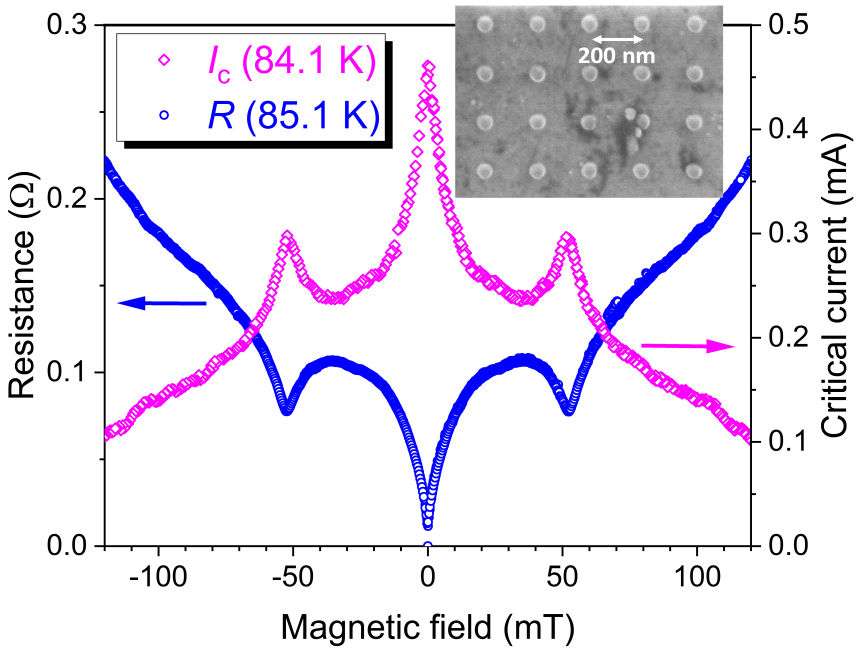

Figure S1: Critical current I_c and resistance R of a 80-nm thick YBCO film, irradiated in a HIM with a square pattern of beam spots (50 nm FWHM) with a lattice constant of 200 nm. The matching field determined from the geometric parameters is $B_m = 52$ mT and leads to a peak in the critical current and a minimum of the resistance. Inset: HIM image of a square array of defects induced by the focused ion beam of the HIM. Irradiation was performed with 5×10^6 ions/spot to visualize the pattern, a much larger fluence than it was used for preparation of the actual sample.

A square array of columnar defect cylinders (CDs) has been fabricated in the helium ion microscope with an intentionally defocused ion beam of FWHM = 50 nm and point-to-point distance $a = 200$ nm in a 80-nm thick YBCO film. The parameters were chosen similar to previous experiments performed with masked ion beam irradiation.[1–4] The critical current $I_c(B_a)$ shows a distinct peak and the magnetoresistance $R(B_a)$ a minimum when each defect is filled with one vortex at an applied magnetic field B_a that fulfils the matching condition for single-vortex occupation of every CD, $B_1 = \Phi_0/a^2$, where Φ_0 is the magnetic

flux quantum and $a = 200\,\mathrm{nm}$ the lattice constant of the square pinning array. The vortex commensurability effects displayed in Fig. S1 appear exactly at the calculated matching field $B_1 = 52\,\mathrm{mT}$.

References

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