Visualization of Different Regimes of Localized Superconductivity in Superconductor-Ferromagnet-Hybrids by Low-Temperature Scanning Laser Microscopy

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We studied the effect of a stripe-like domain structure in a ferromagnetic $BaFe_{12}O_{19}$ substrate on the superconducting properties of Pb thin film microbridges. The nonuniform component of the magnetic field, induced by the ferromagnet leads to a complex $H-T$ phase diagram with various localized states such as reverse domain, domain wall and edge superconductivity. Here we report on low-temperature scanning laser microscopy imaging of these nonuniform superconducting states in a Pb bridge with domain walls perpendicular and a Pb bridge with a single straight domain wall along the center of the bridge. At a temperature slightly below T_c and a bias current smaller than the critical current, the scanning laser spot locally destroys superconductivity by heating up the spot area above T_c or reducing the critical current density below the applied bias current density. This results in a global change of the voltage drop ΔV, which is detected by lock-in technique as a function of the beam spot coordinates (x, y). The acquired voltage images $\Delta V(x, y)$ confirm the formation of inhomogeneous superconducting states and external-field-controlled switching between the normal state and inhomogeneous superconductivity.