Giant Superconducting Diode Effect From Controlled Edge Asymmetry

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Superconducting thin film strips displaying a polarity-dependent critical current, superconducting diode rectification behavior, can be controlled via a small magnetic field. This could serve as an energy-efficient building block for digital circuit logic, similar to semiconductor diodes. Both the Meissner screening effect and symmetry breaking of the two edges in a given superconducting thin film were found to be necessary for V superconducting films to display the rectification. Edge defects asymmetrically lower the Bean-Livingston surface barrier to vortex entry, as well as induce the current crowding effect, both of which increase diode efficiency. In previous studies, edge symmetry breaking was not controlled, and was unavoidable in the fabrication process. Edge symmetry can be broken by modulating via engineered edge geometry. We aimed to control the asymmetry of the two edges in V superconducting thin films by patterning rectangular indentations on only one of the two edges. This allowed us to more than double diode efficiency in pure superconductor thin films (with diode efficiency reaching 40%), opening the door for further improvement in creating highly efficient superconductor diodes. Thus, we show that by optimizing/tuning one edge of a simple superconductor thin film, and by adding a small external magnetic field, one can achieve a very large diode efficiency. Indeed, much larger than has been extensively reported on in far more complex superconductor diodes in recent literature.