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Focused Helium Ion Beam Irradiated Josephson Junctions and Arrays

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We have fabricated Josephson junctions and arrays with a focused helium ion beam from Y-Ba-Cu-O, a high temperature superconductor. *The Josephson junction is the fundamental building block of most superconducting electronics. Normally the size of a junction is chosen to be less than the Josephson penetration depth (λ_J) ~4 μm, a fundamental length scale for superconducting devices, because it ensures that the supercurrent is distributed evenly throughout the junction. For a static current biased Josephson junction or array of junctions, the voltage across the device modulates in a magnetic field. The voltage as a function of magnetic field (*V-B*) of an ideal Josephson junction goes as*|sin(B×A)/(B×A)|.*Where*B×A*is the product of applied magnetic field B and junction area, A. When the length of a junction becomes larger than λ_J, the*V-B*comes more triangular and asymmetric. As a result, this improves the linearity of the Josephson based voltage magnectic field transducing devices. In addition, the skewing of the*V-B*makes one side of the peak extremely sharp that enhances the sensitivity* (dV/dB*) to detect small fields.

In our work, we will present the fabrication process and measurement results of Josephson junctions and arrays with widths that range from 1 micron to 30 microns. These devices were fabricated with 30 nm Y-Ba-Cu-O films grown by reactive coevaporation. After patterning the large features and electrodes of the devices with standard photolithography and Ar ion beam etching, the junctions were directly written using a 30 keV focused helium ion microscope with doses of 1016~1017 ions/cm². Our results show that Josephson junctions and arrays have great potential for large dynamic range for advanced magnetic antennas for communications.

[*] Cybart, Shane A., et al. “Nano Josephson superconducting tunnel junctions in YBa2Cu3O7–δ directly patterned with a focused helium ion beam.” Nature nanotechnology 10.7 (2015): 598-602.

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