Focused Helium Ion Beam Josephson Junctions and Nanowires

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Nearly three decades have passed since the discovery of high-T_C superconductivity and progress in high-T_C devices has been very slow because process control at the sub ten nanometer scale is required to make reproducible Josephson junctions: the basic building block of superconducting electronics. Gas field focused helium ion beams[1] provide a new promising approach for direct-write lithography of these materials[2] for the realization of a manufacturable high-T_C superconducting electronics technology. The key to the direct-write method is that high-T_C superconductors are very sensitive to point defects in the crystal lattice caused by ion irradiation.[3] Increasing irradiation levels has the effects of increasing resistivity and reducing the superconducting transition temperature. At very high irradiation levels the material becomes insulating and no longer conducts or superconducts.[3] In this work, we use the finely focused ion beam of the Zeiss Orion helium ion microscope to create nano scale insulating features within the plane of a thin film to create Josephson junctions and nanowires. By controlling the irradiation dose we can create very high-quality Josephson junctions with both metallic and insulating barriers. The observation of quasiparticle tunneling in these devices provides strong evidence that a high quality insulating barrier less than a few nanometers wide was created. I will present recent results obtained from our direct write studies that include electrical transport data for magnetic nanowire and Josephson devices, followed by a discussion of the future possibilities of helium ion modification of oxides.

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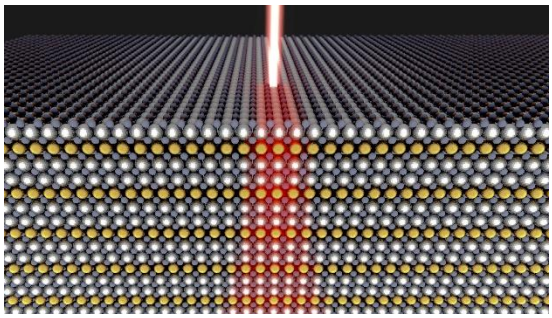

Figure 1: Scale model of a focused helium ion beam locally disordering a $YBa_2Cu_3O_7$ crystal which changes the electrical properties from superconductor to insulator.