High Temperature Superconducting Electronics for Biomedical Imaging and Advanced Communications

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Superconducting electronics, due to their quantum mechanical nature on a macroscopic scale, have some very unique properties that cannot be achieved with conventional charge-based electronics. Superconducting electronics host the potential of lower power supercomputers, quantum computers, DC-THz wide band receivers, noninvasive imaging for fault detection or noninvasive biomedical imaging of brain or other organs, geo-survey for mineral and oil excavation, etc. The operating temperature of conventional metallic superconductors is prohibitive for widespread use of the different applications due to the high cooling costs and difficulty of operation near (4K). The discovery of high-transition-temperature-superconductor (HTS) in the 1980's ignited the dream of widely applicable superconducting electronics. Unfortunately, HTS turned out to be more complicated and harder to control than anticipated. This complicated the fabrication of high-quality Josephson junctions. Recently, due to advances in nanotechnology, namely in focused ion beam technology, a process that uses a focused helium ion beam to direct write Josephson junction in Y-Ba-Cu-O has been developed (Fig. 1).[1] Our patented process shows promise for scalable, reproducible and low cost Josephson junctions. Furthermore, it boasts a high level control over many junction parameters such critical current, normal state resistance, capacitance, and operating temperature all at once and independently with irradiation dose and the geometry of the junction. Here we will discuss the demonstrated results and how they will impact biomedical imaging and communication devices.

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[1] Cybart, S.A., Cho, E.Y., Wong, T.J., Wehlin, B.H., Ma, M.K., Huynh, C. and Dynes, R.C., 2015. Nano Josephson superconducting tunnel junctions in $YBa_2Cu_3O_{7-\delta}$ directly patterned with a focused helium ion beam. *Nature nanotechnology*, *10*(7), pp.598-602.

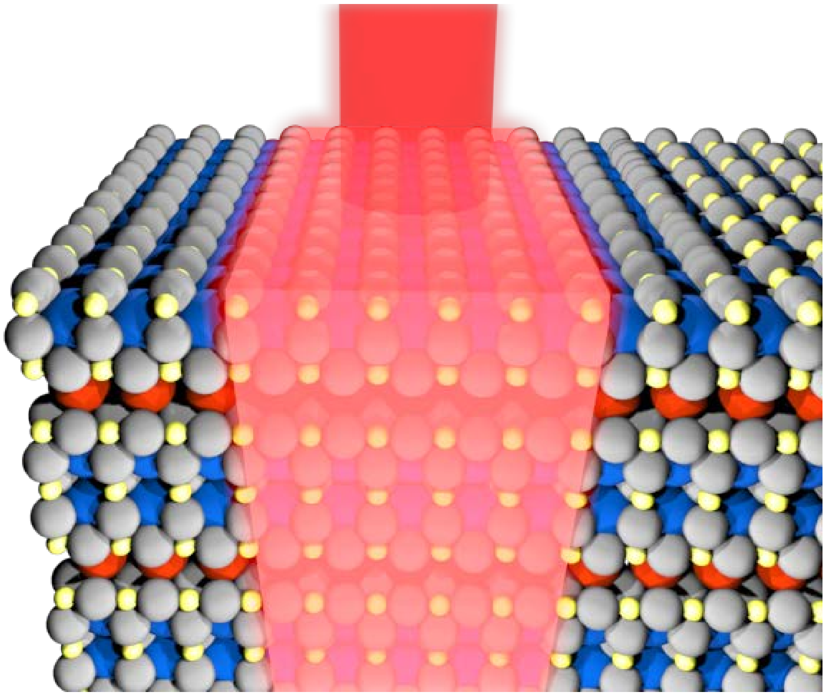

Figure 1. An illustrative picture of Y-Ba-Cu-O crystal lattice irradiated with 0.5 nm focused helium ion beam. The red area indicates the Josephson junction barrier.