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M3Or1B-02 [Invited]: Planar MgB2 Josephson junctions and arrays made by focused helium ion beam

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Planar MgB2 Josephson junctions and series arrays were fabricated by focused helium ion beam irradiation. This technique forms a junction barrier with the use of a 30 keV focused helium ion beam, nominal beam diameter of less than 0.5 nm and dose of 0.9 ˜ 3 × 10ˆ16 ions/cmˆ2, to locally damage a 25 nm-thick MgB2 thin film grown by hybrid physical-chemical deposition on SiC (0001). The Josephson junctions exhibit RSJ-like I–V characteristics at 12˜27 K with a typical IcRn of 70 μV at 20 K that can be described by the superconductor-normal metal-superconductor Josephson junction model at the dirty limit. The Josephson effects of the junctions were verified by observing the Fraunhofer pattern of the critical current under applied magnetic field and the Shapiro steps on the I–V characteristics under microwave radiation. Junction arrays consisting of up to 70 junctions in series, with junction space period of 100 nm, show less than 4% spread in critical current at 12 K. Under microwave radiation, flat Shapiro steps up to 150 μA appear at voltages Vn = Nnf/Φ0, where N is the number of junctions in the array, n is an integer index of the Shapiro step, Φ0 is the magnetic flux quantum, and f is the applied microwave frequency. The greatly reduced spread in critical current is a significant improvement over junctions made by any other techniques. This breakthrough may lead to applications including Josephson voltage standards and arbitrary function generators that can work at around 20 K.

[1] L. Kasaei et al. AIP Advances 8, 075020 (2018); https://doi.org/10.1063/1.5030751

[2] L. Kasaei et al. IEEE Transactions on Applied Superconductivity, 29 (2019); https://doi.org/10.1109/TASC.2019.2903418

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