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Serial arrays of high-T_c SQUIDs with graphoepitaxial step edge junctions

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Direct coupled high-T_c DC SQUIDs require the deposition of only a single superconducting layer, can be fabricated using a minimal number of technological steps and provide a magnetic field resolution of approximately 10 fT/rt(Hz) at 77 K, which is sufficient for applications in geomagnetic surveys, non-destructive evaluation and even biomagnetic measurements. If such SQUIDs are made using step edge Josephson junctions, then they potentially permit the simultaneous fabrication of many sensors on large area substrates, in close proximity to objects of interest that can be kept at room temperature.

The use of novel graphoepitaxial step edge Josephson junctions on buffered MgO substrates [1] has been used to overcome the poor reproducibility of conventional step edge high-T_c Josephson junctions, thanks to the self-arranged growth of two identical [100]-tilted 45 degree grain boundaries over a wide range of slope angles and step heights on MgO substrates. The implementation of such junctions has resulted in a doubling in voltage swings and I_cR_n-product, when compared with SQUIDs prepared using conventional step edge or bicrystal high-T_c Josephson junctions.

Additional improvements in SQUID parameters have been achieved by using serial arrays of SQUIDs. The use of a dual-SQUID configuration is a well known technique for further improving voltage swings and flux noise in high-T_c SQUIDs (see [2] and references therein). Unfortunately, the reproducibility of the parameters in conventional high-T_c junctions has not been sufficient to make use of the advantages of a dual-SQUID configuration, with the decoherence of Josephson oscillations in junctions that have different critical currents often preventing the doubling of voltage swings. Only graphoepitaxial SQUIDs possess the required properties, as demonstrated by measurements of electron transport and microstructure for different junction types. This contribution will describe our technology for the preparation of epitaxial metal-oxide heterostructures, graphoepitaxial high-T_c step edge Josephson junctions and dual type direct coupled DC SQUID magnetometers and gradiometers, as well as measurements of their electron transport properties and microstructures by high-resolution SEM, AFM and high-resolution TEM. A possible use of superconducting multilayer flux transformers with high-T_c SQUID arrays will also be discussed.

[1] M. I. Faley, *Patent* DE102012006825 (2012).
[2] K.-L. Chen et al., *Journal of Appl. Phys*. **108**, 064503 (2010).