High Current Density SIS Junctions Based on Nb/Al,AlN/Nb Tri-layers

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We have successfully fabricated superconductor-insulator-superconductor (SIS) junctions with current densities ranging from 10 – 30 kA/cm^2. Junction *IV*-characteristics, measured at 4 K, show normal state to sub-gap resistance ratios of ~12 and gap voltages 2.8-2.9 mV. For current densities beyond 30 kA/cm^2 junction quality slowly starts to degrade. The gap voltage can be tuned by varying the thickness of the Al over layer, estimated to be 6-8 nm. The Nb/Al,AlN/Nb tri-layers are made in a dual chamber system with ultra-high vacuum capability. Nb and Al films are deposited by magnetron sputtering in the first chamber. A second adjacent chamber is equipped with an inductively coupled plasma source which allows the formation of the ultra-thin aluminium nitride barrier. The system configuration is similar to the ones reported in [1] and [2]. We have systematically investigated the relation between nitridation conditions, e.g. nitrogen flow/pressure, plasma source to substrate distance and power input, and the resulting junction properties. While a fixed set of parameters determines the nitridation rate, we found that nitridation conditions do not influence the junction quality. The presence of rest gases such as water and oxygen in the nitridation chamber is critical for the reproducibility of the nitridation rate. Extra measures were taken to keep those rest gas levels at a minimum.
SIS mixers based on these high-j_c junctions are potentially interesting for heterodyne receivers where a high fractional bandwidth is required.

REFERENCES

[1] T. Cecil et al., "Investigation of NbTiN Thin Films and AlN Tunnel Barriers With Ellipsometry for Superconducting Device Applications," *IEEE Transactions on Applied Superonductivity*, vol. 17, no. 2, 2007.
[2] T. Zijlstra et al., "Epitaxial aluminium nitride tunnel barriers grown by nitridation with a plasma source," *Applied Physics Letters*, vol. 91, 2007.

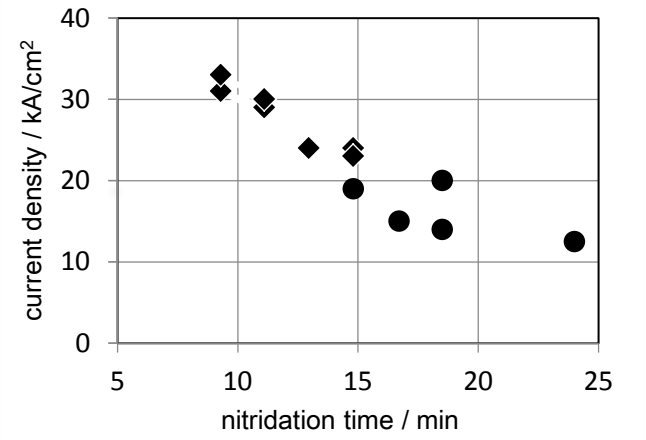

Fig. 1 Junction current density as a function of nitridation time. Nitrogen pressure 30 mtorr, RF power coupled to plasma 440 W, plasma source-substrate distance 15 cm (●), 17 cm (♦).

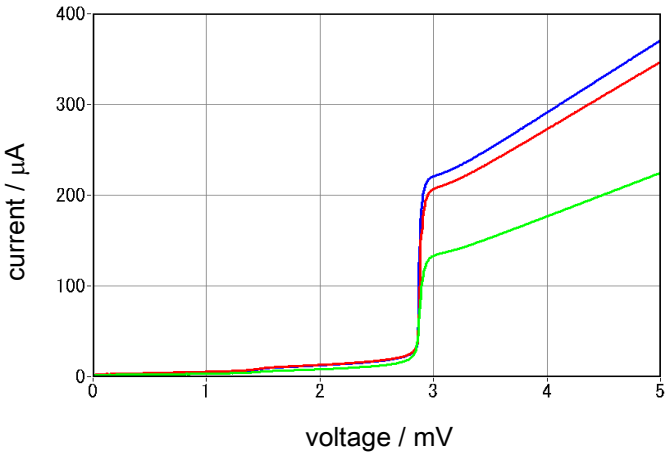

Fig. 2 *IV*-characteristics of junctions with nominal diameter ϕ_j=1 µm (blue, red) and ϕ_j=0.75 µm (green). The current density is about 24 kA/cm^2.