In recent years, alternatives to bulk Nb, including novel materials and fabrication techniques, have been extensively explored by the SRF community. One of these new methodologies is the use of a superconductor-insulator-superconductor (SIS) structure. Typically, these have been envisaged for use with bulk Nb cavities. However, it is also conceivable to apply SIS film coatings to Cu cavities, which have the advantage of being able to operate at 4.2 K. This can potentially delay the onset of the Q-slope observed with coated Cu cavities.

In light of this, two series of multilayer SIS film coatings, with a Nb-AlN-NbN structure (Fig. 1 (a)), were deposited onto electropolished OFHC Cu samples, with the use of HiPIMS, in order to determine the efficacy of this approach. The critical difference between the two series was the NbN coating pumping speed, with the lower pumping speed used in series 1 resulting in pressure fluctuations during the coating. The thicknesses of both the AlN and NbN layers were varied, indicated in fig. 1 (b) and (c).

### Morphological and Topographical Results

- The resultant surface grain morphology is dominated by the underlying Nb base layer. The NbN is essentially "superimposed" on top of the Nb grains. A multitude of different grain structures are observed, detailed in fig. 2.
- HiPIMS deposition lead to significant improvements to the base Nb layer and a rounding of the NbN film surface, both of which resulted in a subsequent lower surface roughness compared to previous DC MS results.
- TEM investigations (fig. 3) revealed no interfacial voids between the Nb base layer and the Cu substrate or between the subsequent NbAlN and AlN/NbN layers.
- The layers display coherent, epitaxial growth on top of one another.

### Superconducting Results

- Nb $T_c = 9.3$ K, consistent with individual layers. Decreased NbN $T_c$ in first series compared to individual layers.
- Increasing NbN $T_c$ with increasing AlN and NbN thickness. NbN layer thickness of 180 – 200 nm provides optimal shielding performance based on $H_n$.
- Highest SIS film $H_n = 88.0$ mT achieved with HiPIMS deposition (compared to 64.5 mT achieved with DC MS).
- Significantly improved magnetisation loops showing good reversibility and low amounts of trapped flux. Lower AlN thickness (10 nm here) leads to lower trapped flux.

### Conclusions

- HiPIMS deposition significantly improves the density of the deposited SIS films, leading to decreased oxygen content in the NbN layer and improved surface roughness.
- Coherent, epitaxial layers successfully grown via HiPIMS.
- Increased AlN layer thickness leads to increased NbN $T_c$ and improved $H_n$. Thinner AlN layer results in smaller magnetisation loop and lower levels of trapped flux.
- Two QFP samples were coated with HiPIMS SIS films with different AlN layer thicknesses. Detailed investigation presented in SUPFDV006.

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