INFLUENCE OF THE COATING PARAMETERS ON THE T_c OF Nb_3Sn THIN FILMS ON COPPER DEPOSITED VIA DC MAGNETRON SPUTTERING

SUSPB007 SRF 2023 GRAND RAPIDS

INFN LNL

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Why Cu substrate

- **Cheaper** than Nb
- **Higher thermal conductivity** than Nb
- **Cooling by cryocooler** possible (open to industrial application)
- PVD on Cu is a **well establish technology for SRF**

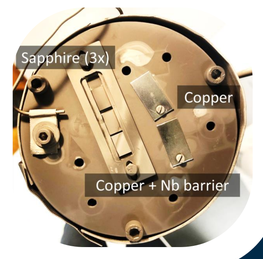
Experimental methods

Nb_3Sn thin film deposition on: sapphire, copper and copper with Nb buffer layer; later runs also copper with 30 μm Nb buffer layer

Nb_3Sn deposited via **DCMS** from 4" planar stoichiometric target in argon atmosphere

Process steps: 48 h baking → 6h - 10h coating → 24h (or less) annealing

Characterisation: **T_c inductive** (90%- 10% method for value extraction), **SEM**, **EDS**, **XRD**



Why Nb_3Sn for SRF

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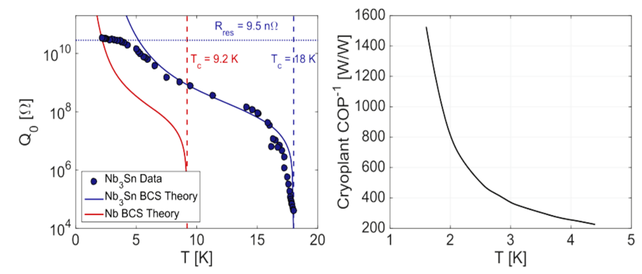
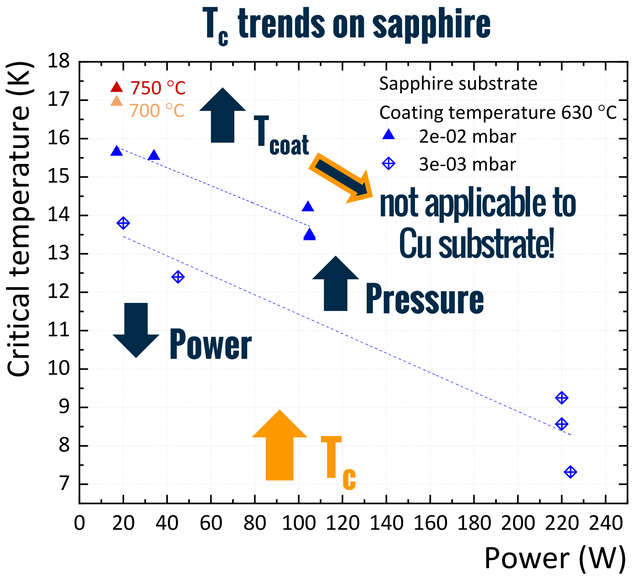


Bulk Nb has reached **limit performance**: $Q_0 \sim 10^{10}$ @T_{op} = 2 K with gradient closer to H_{sh}

T_c Nb_3Sn = 18.3 K
Needed Cryopower reduced by factor 3

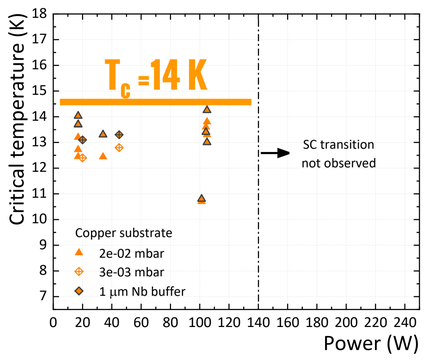
T_c dependencies on coating parameters

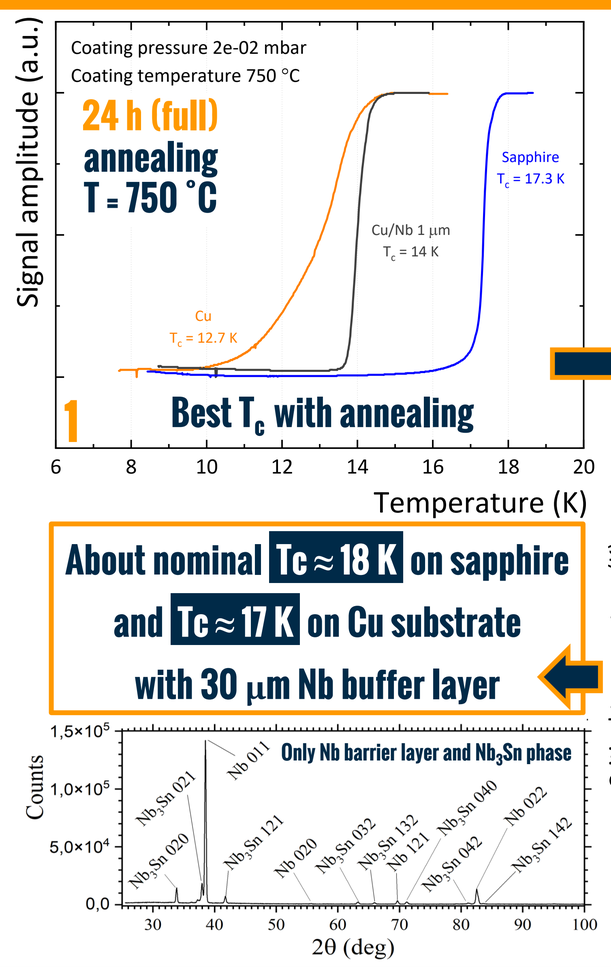
T_c trends on sapphire

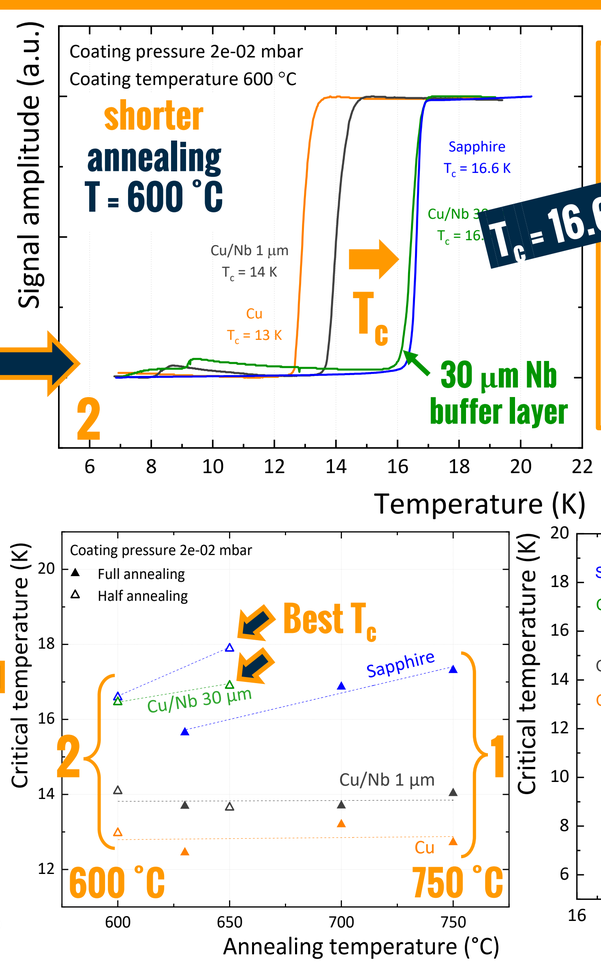


No trends on copper

Better T_c on Nb buffer layer (less Cu-Sn interdiffusion)





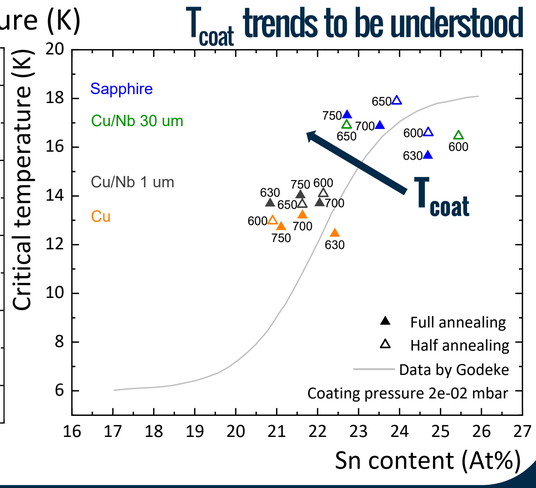


Shorter annealing
Thicker Nb buffer layer
Lower T coating (👍 on Cu)

T_c on Cu with 30 μm Nb buffer
=
T_c on sapphire
(and sharper SC curve on Cu)

About nominal Tc ≈ 18 K on sapphire and Tc ≈ 17 K on Cu substrate with 30 μm Nb buffer layer

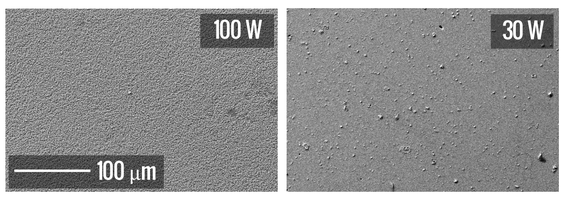
T_{coat} trends to be understood



Surface analysis

CATHODE POWER

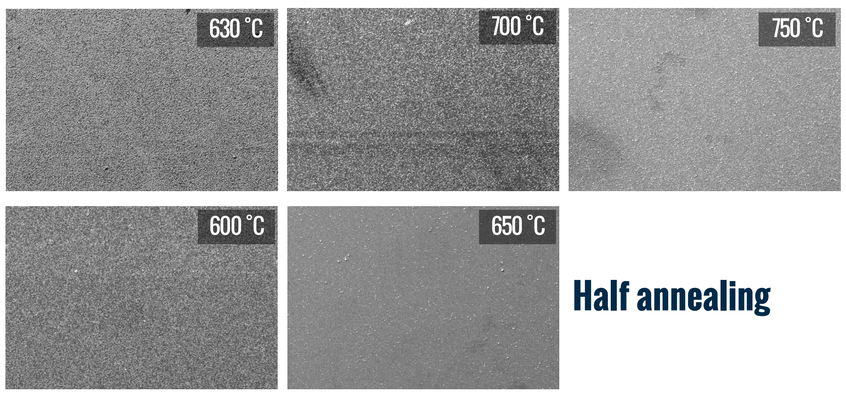
Coating pressure = 2e-02 mbar, coating temperature = 630 °C



Increasing the process/annealing temperature mitigates tin clustering and affects T_c positively

COATING TEMPERATURE

Coating pressure = 2e-02 mbar, cathode power = 20 W



Full annealing

Half annealing

Conclusions

- **Nb3Sn/Cu recipe optimisation** via feedback loop coating parameter choice
- **High pressure** (2e-02 mbar in Ar) and **low power** (20 W) as base parameters from results **on sapphire**
- T_c observed to improve with temperature on sapphire substrate, although **not applicable to large copper structures** such as cavities
- **Increasing the thickness (1 μm → 30 μm) of the Nb buffer layer and shortening the annealing times successfully increased the T_c on copper with results comparable to T_c on sapphire**
- **Temperature dependencies** still under investigation, planned exact quantitative analysis of **Nb-Sn composition via XRF**, **XRD** analysis ongoing
- Next step assessment of **RF performance**

iFAST

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