RF Surface Resistance Measurements on Planar Samples at STFC

9th IFAST WP9 Meeting
18th April 2023

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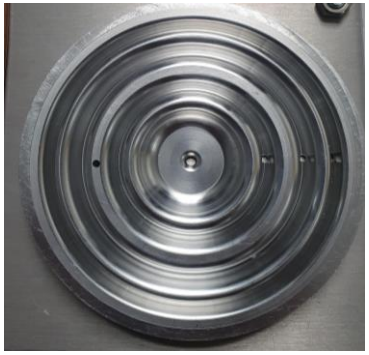
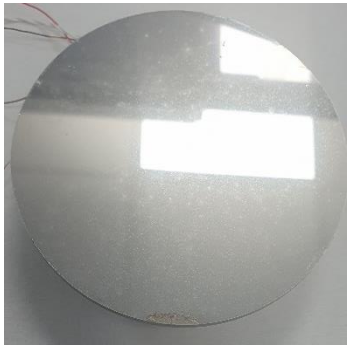
Facility Reminder

The Choke Cavity Facility

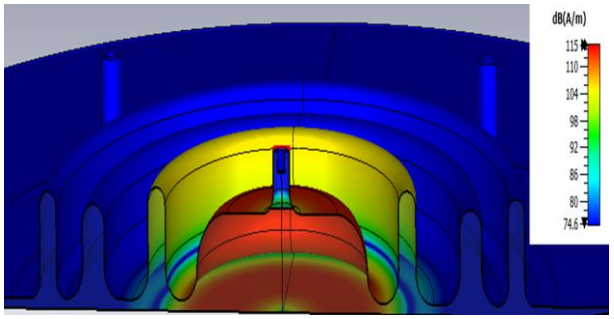
- **Two part test cavity in LHe-free cryostat:**
  - Bulk Nb choke cavity
  - Planar disk - **90 - 130 mm** diameter, **1 – 10 mm** thickness
- **RF-DC compensation** → $R_S(T, B)$
- **VNA measurements** → Δf → $\Delta\lambda$
- **Parameters:**
  - f_0 = 7.8 GHz
  - $T_{Sample} \geq 4$ K
  - RF Power up to 1 W (for now!)
  - $B_{sample,\,pk} \leq 1$ mT



Choke cavity

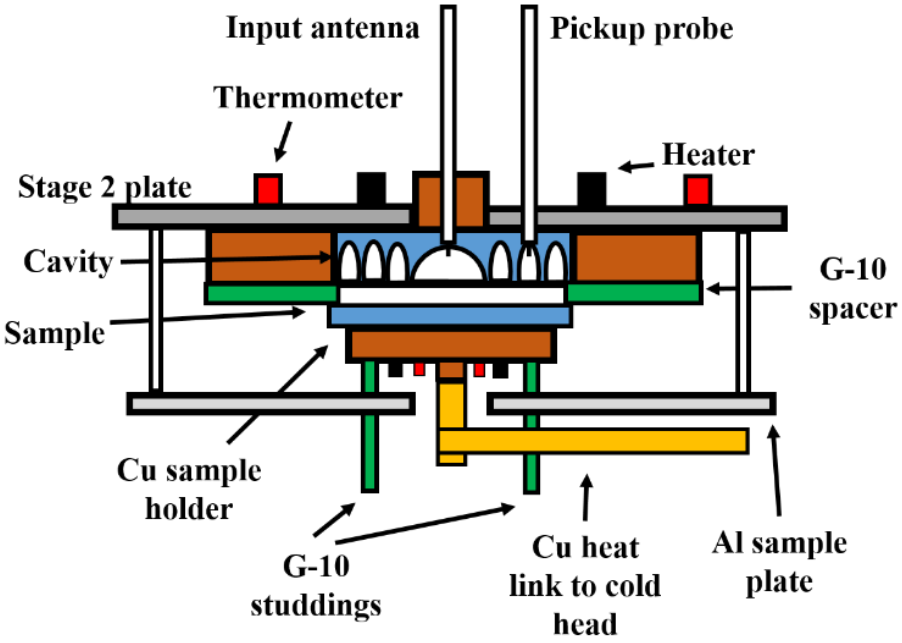


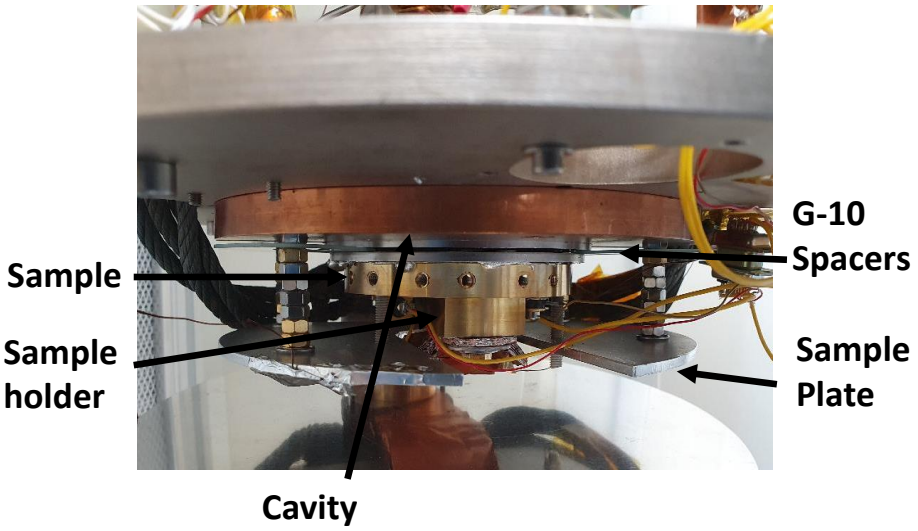
Planar disk



***B*-fields**

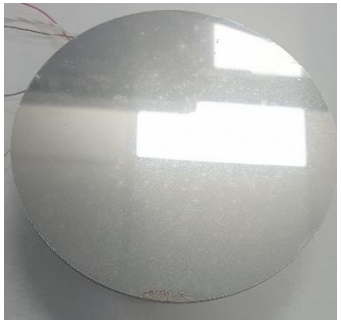
The Choke Cavity Facility





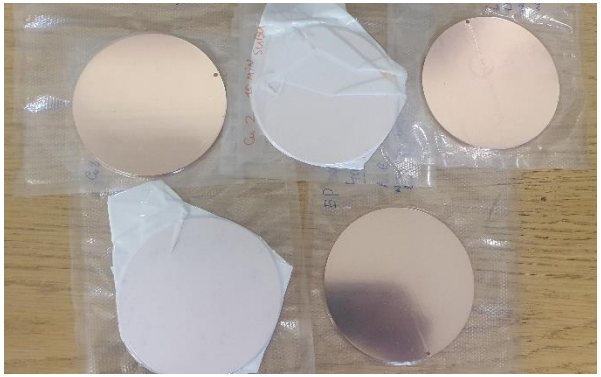
1 sample test ($R_s(T)$)/2 days

Cu Samples



Diamond Turned (DT) from RAL
(S_a ~ 2-3 nm, S_q ~ 5-6 nm)

Metallographic Polishing (MP) from IJCLab
courtesy of D. Longuevergne & O. Hryhorenko
(S_a ~ 20 nm, Ave S_z ~ 2.5 µm)

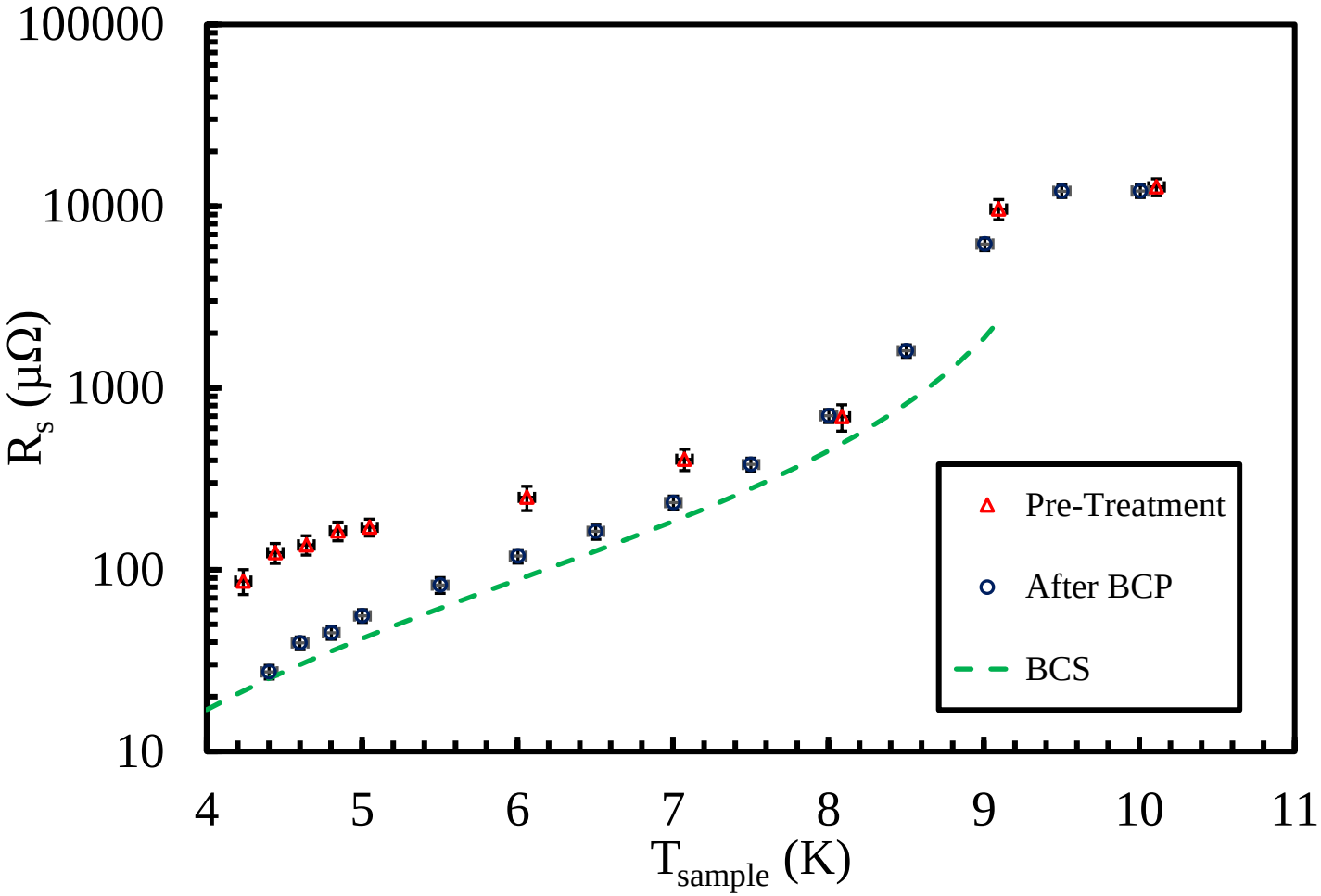


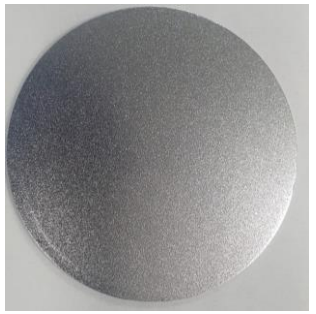
EP, SUBU, EP + SUBU from INFN
courtesy of E. Chyhyrynets and C. Pira

Samples are indium brazed to sample holder under vacuum at ~ 160 °C

RF Measurements of a Bulk Nb Sample

Bulk Nb





Bulk Nb: *RRR* = 300**,** BCP with 60-100 μm removed *courtesy of E. Chyhyrynets*

*** 4 more bulk Nb** (*RRR* = 300) available for treatment

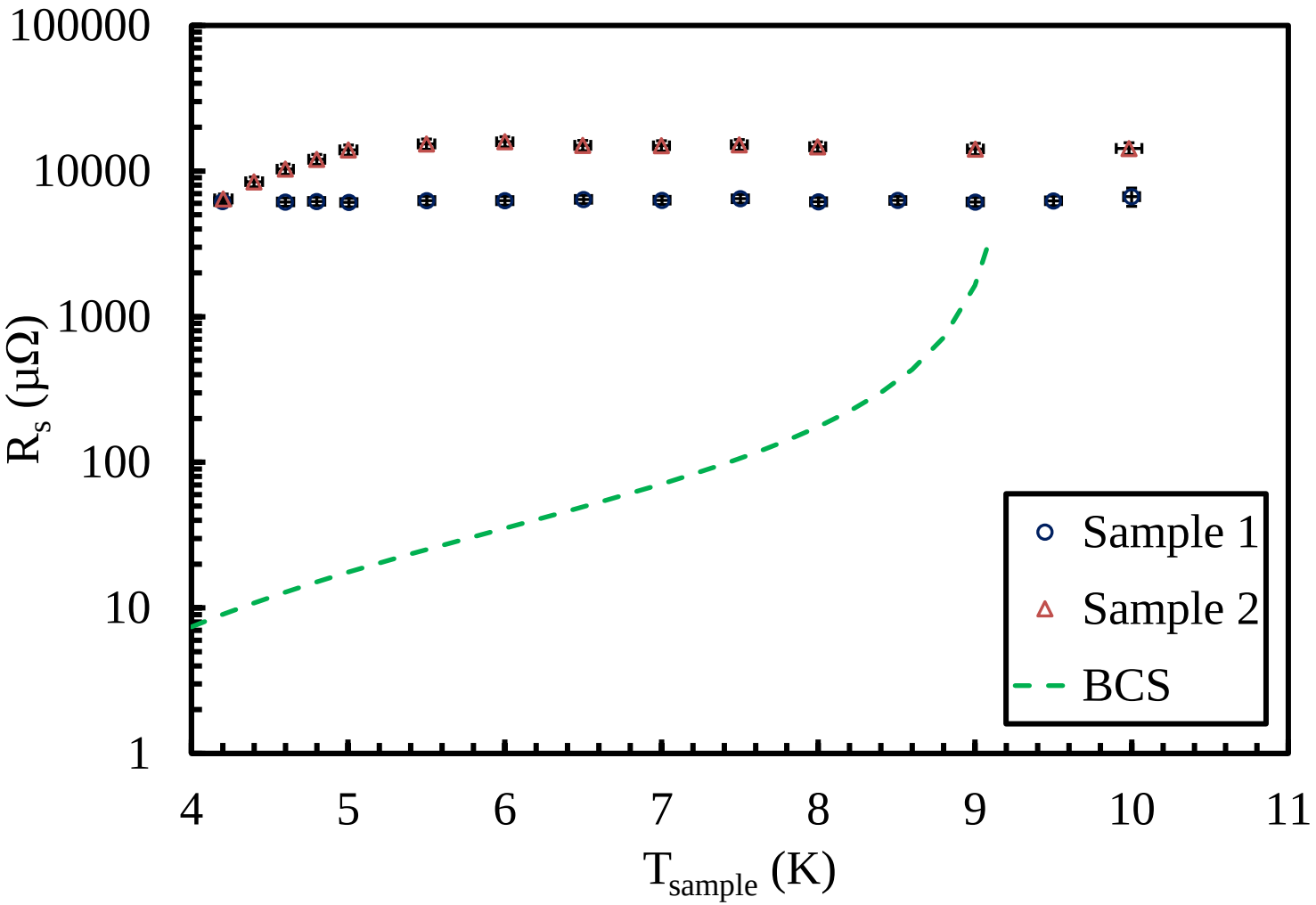
RF Measurements of Nb on Cu Samples

Nb on Cu Samples Tested

Sample	Substrate Preparation	Deposition Temperature (°C)	~ Thickness (µm)
Effect of film thickness with DC magnetron			
1	DT	300 - 350	0.6
2	DT	300 - 350	1.2
Effect of deposition temperature with HiPIMS			
3	DT	400 - 450	3
4	DT	RT	3
5	DT	300 - 350	3

*** Surface analysis to be shown at 10th meeting**

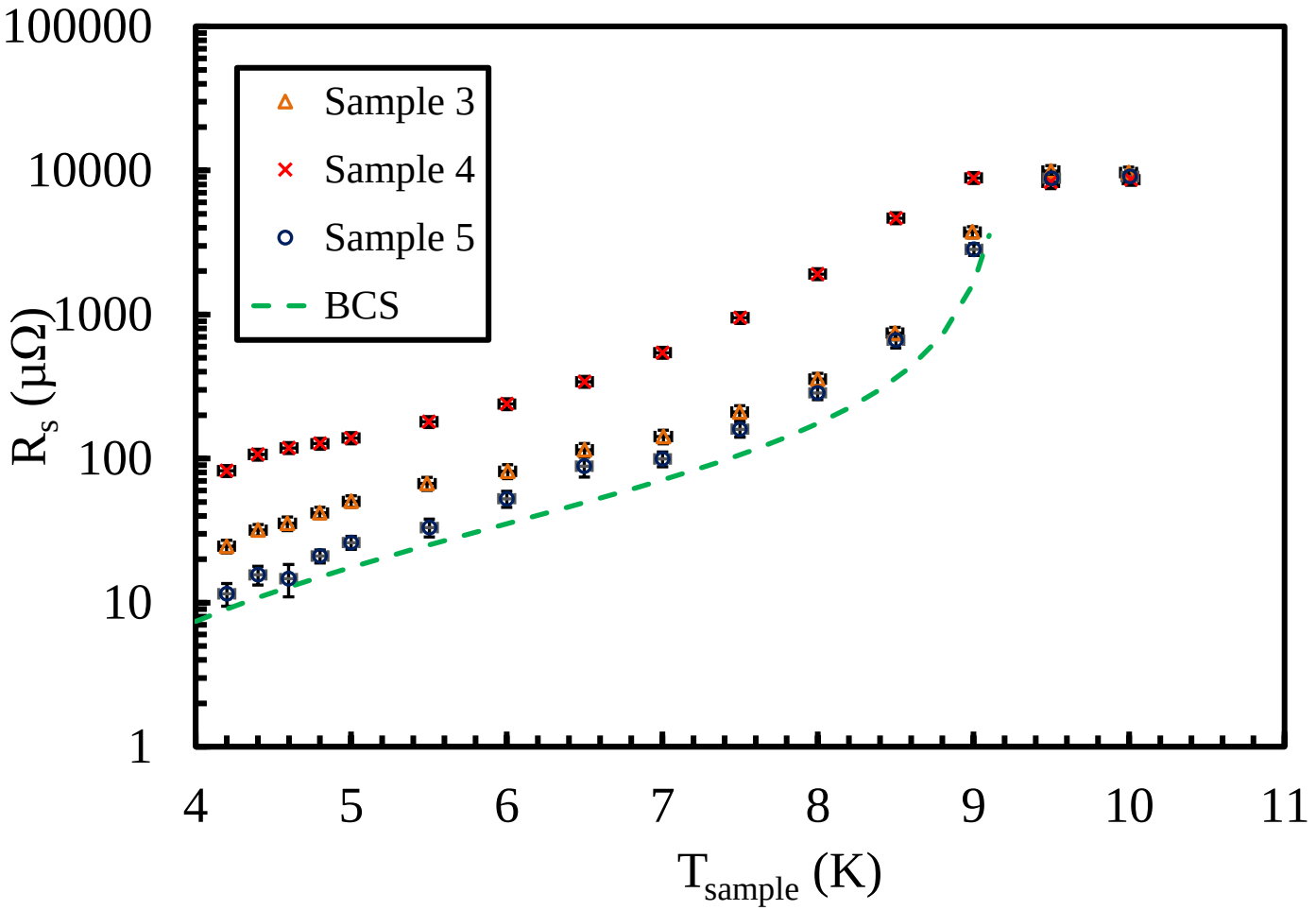
Samples 1 & 2

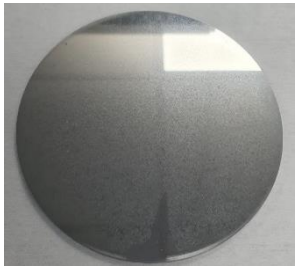


Sample 1: DC magnetron, 300 – 350 °C, ~ 0.6 μm

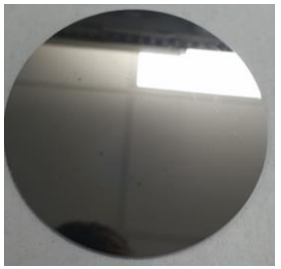
Sample 2: DC magnetron, 300 – 350 °C, ~ 1.2 μm

Samples 3 - 5

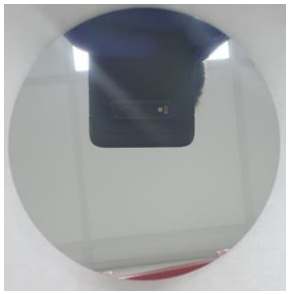




Sample 3: 400 – 450 °C, ~ 3 μm

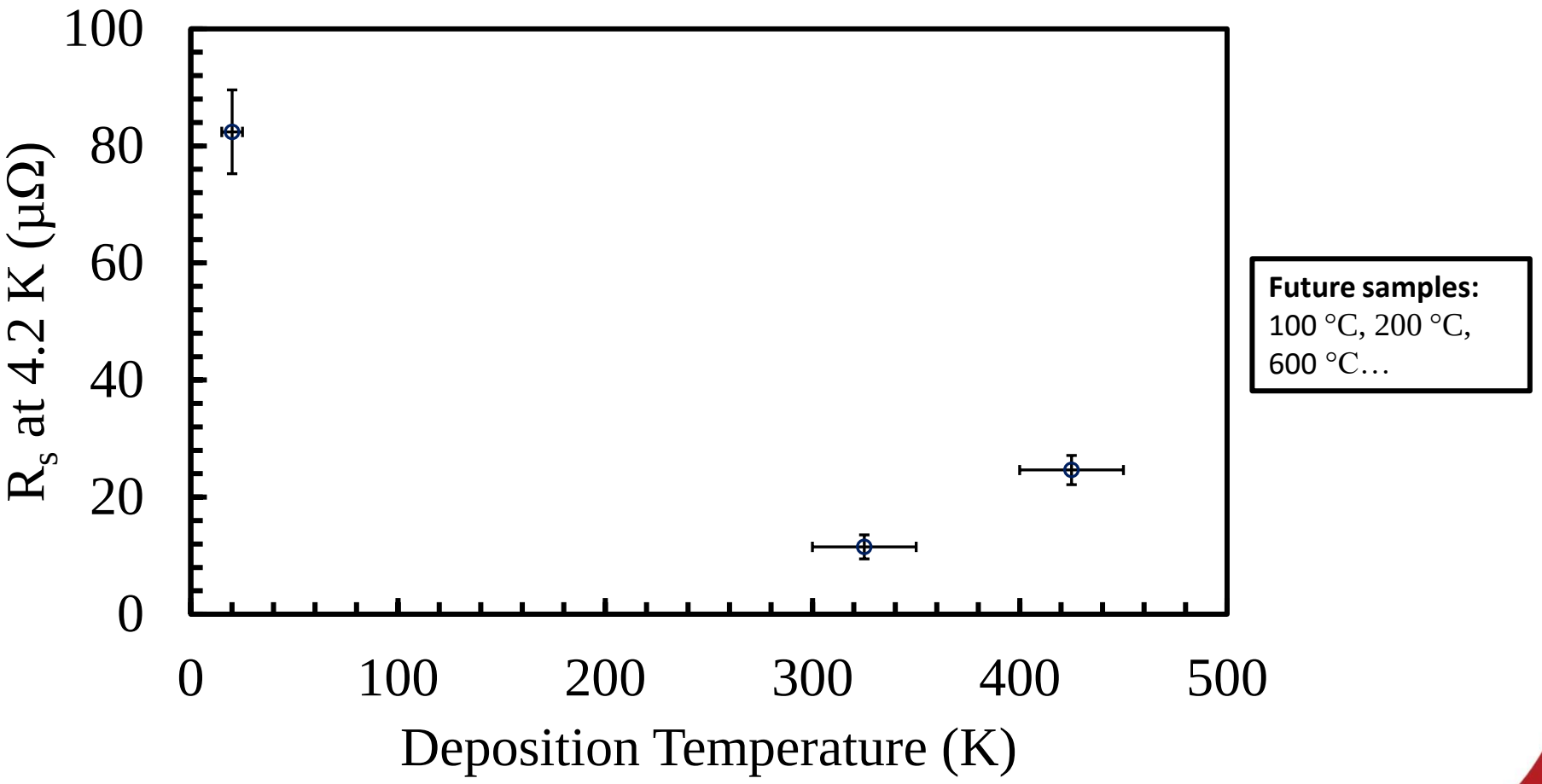


Sample 4: RT, ~ 3 μm



Sample 5: 300 – 350 °C, ~ 3 μm

Samples 3 – 5: towards optimising deposition temperature

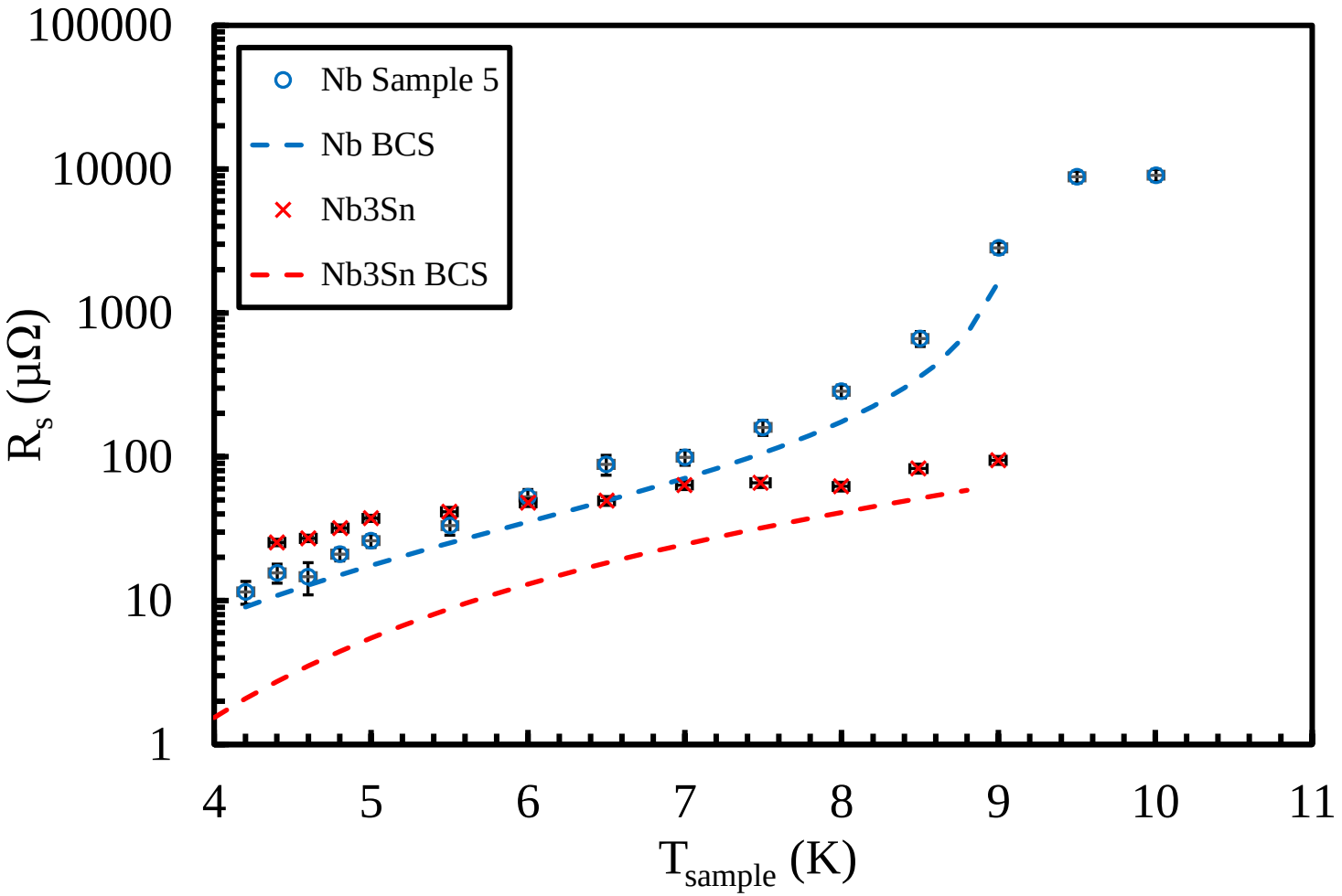


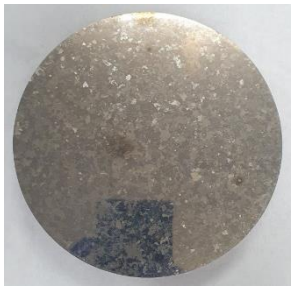
Future Nb Samples

Sample	Substrate Preparation	Deposition Temperature (°C)	Thickness (µm)
Effect of deposition temperature with HiPIMS			
3	DT	400 - 450	~ 3
4	DT	RT	~ 3
5	DT	300 - 350	~ 3
6	DT	600-650	~ 3
7	DT	100	~ 3
8	DT	200	~ 3
Effect of HiPIMS + positive kick			
…	DT	?	~ 3
Effect of substrate preparation			
…	MP, EP, SUBU, EP + SUBU	?	~ 3

RF Measurements of a Nb_3Sn Sample

Nb_3Sn Sample



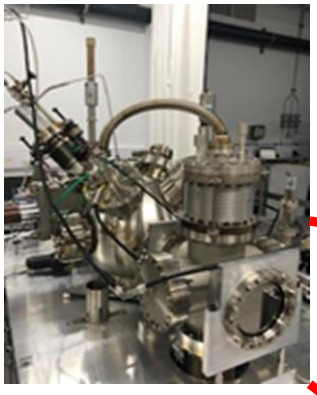


Nb_3Sn Sample: DC magnetron, ~ 600°C, ~ 600 nm

Next Steps

From planar samples to real cavities

Aim: Best performing flat samples → split cavities



3 sets of samples:

1. Nb coated planar samples
   - Low power RF test with choke cavity
   - High power RF test with QPR
2. Split cavity deposited with planar magnetron & planar target
   - RF test
3. Split cavity deposited with cylindrical magnetron & tubular target
   - RF test

Current Status & Future Plans

1. **Optimise parameters of Nb thin films → Baseline for multilayers**
2. **Continue Nb_3Sn, NbTiN, (& V_3Si) single layer studies**
3. **Multilayers (on TF Nb and/or bulk Nb)**

- Cut samples → MFP (Liam) & surface analysis (Reza/Chris) etc
- Test IJCLab treated bulk Nb 2 choke cavity
- Move to an RF bunker → higher peak fields (overlapping with QPR)
- Happy to accept samples on disks 90-130 mm diameter (up to 10 mm thickness)
  - Can provide unpolished or polished (mainly DT) Cu
  - Contact: daniel.seal@cockcroft.ac.uk
- Potential for laser treatment at RTU and/or flash at HZDR?

Acknowledgements

STFC/CI: O. B. Malyshev, T. Sian, R. Valizadeh, P. Goudket, S. Hitchen, L. Smith, J. Conlon, C. Benjamin, S. Wilde, K. Dumbell, N. Pattalwar, S. Pattalwar, A. Blackett-May, F. Lockwood-Estrin, A. Hannah, A. Vick, L. Cowie, S. Bibby-Trevor, R. McAllister, A. Palmer, A. Wooten, K. Morrow, M. Roper, M. Beardsley

Lancaster University/CI: G. Burt, N. Leicester, D. Turner, H. Marks

INFN: C. Pira, E. Chyhyrynets

IJCLAB: D. Longuevergne, O. Hryhorenko

CEA: C. Antoine

Thank you for listening

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