



Advanced Fabrication and Vacuum Compatibility of Tl-1223 Superconducting Thin Films for the Future Circular Collider (FCC-hh) Beam Screen

A. Leveratto, R. Vaglio, M. Putti, C. Ferdeghini, C. Bernini, E. Bellingeri

CNR-SPIN, GENOVA ITALY

S. Hollies, M. Eisterer, J. Bernardi

TU-WIEN, USTEM, ATOMINSTITUT, WIEN, AUSTRIA

S. Calatroni, M. Himmerlich, S. Fernandez-Peña

CERN, GENEVE, SWITZERLAND



OUTLINE



**SUPERCONDUCTING
COATINGS**

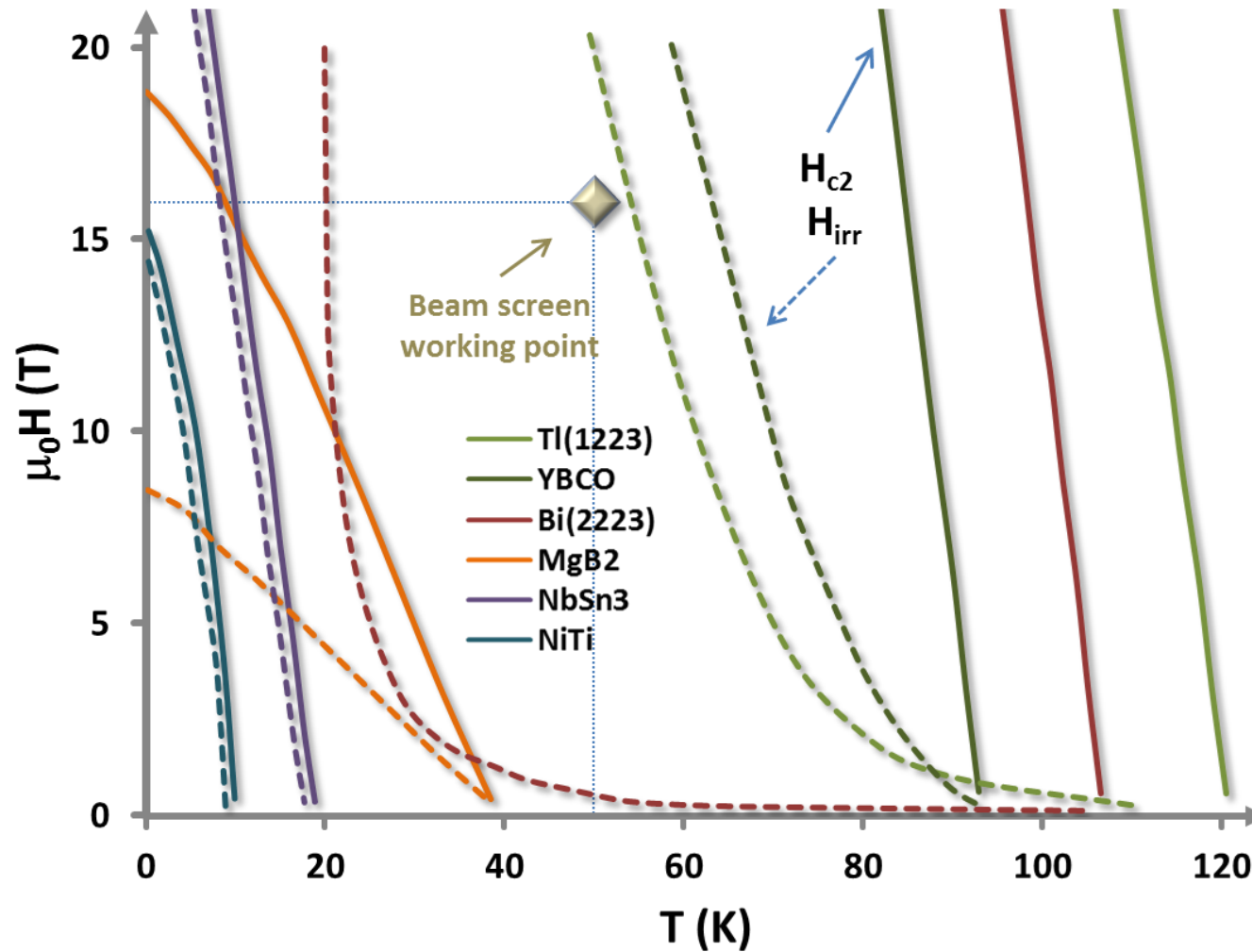


**VACUUM
COMPATIBILITY**



FUTURE STEPS

Why TI-based High temperature superconductors???



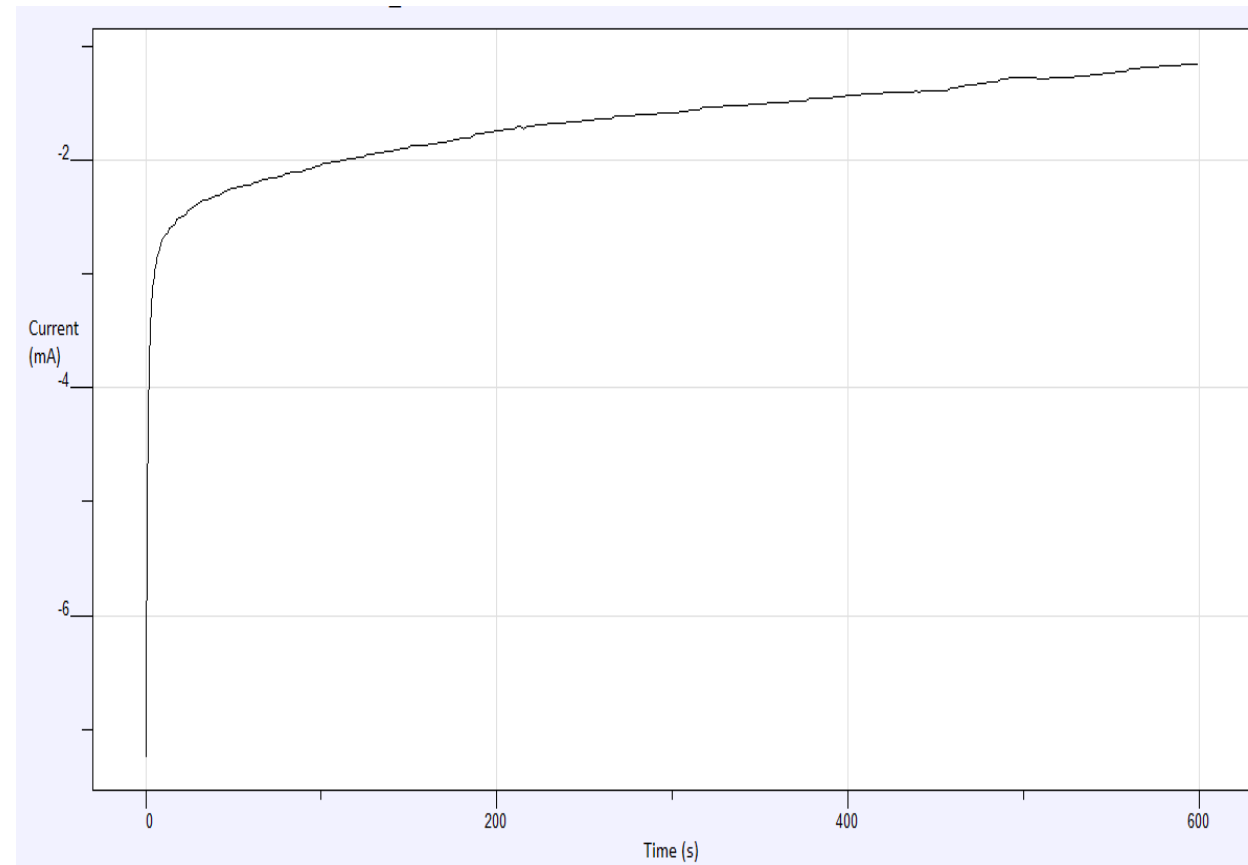
Reference : S. Calatroni, E. Bellingeri, C. Ferdeghini, M. Putti, R. Vaglio, T. Baumgartner and M. Eisterer, 2017 SUST 30 075002



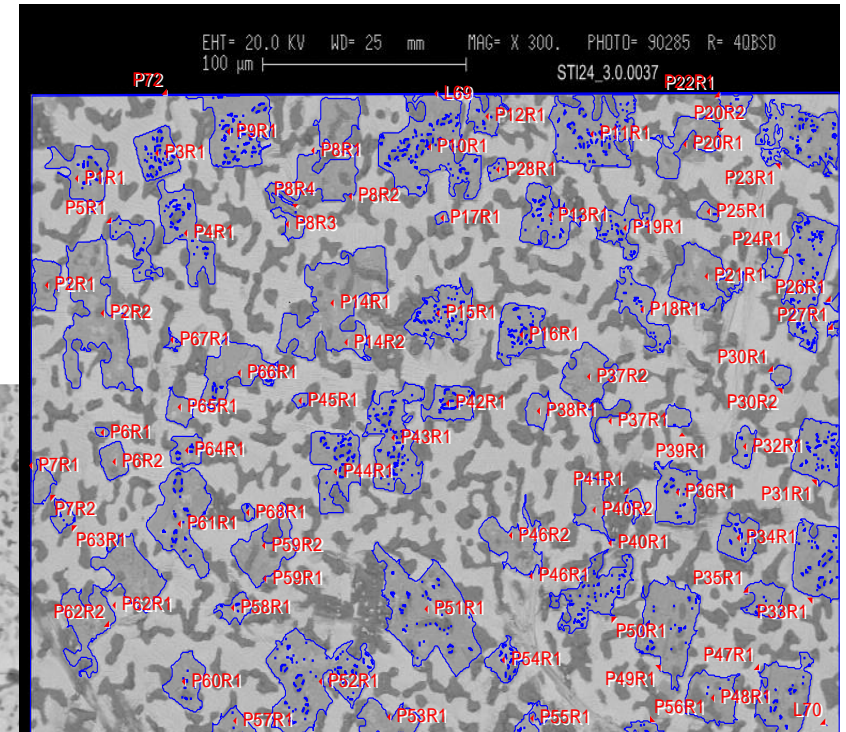
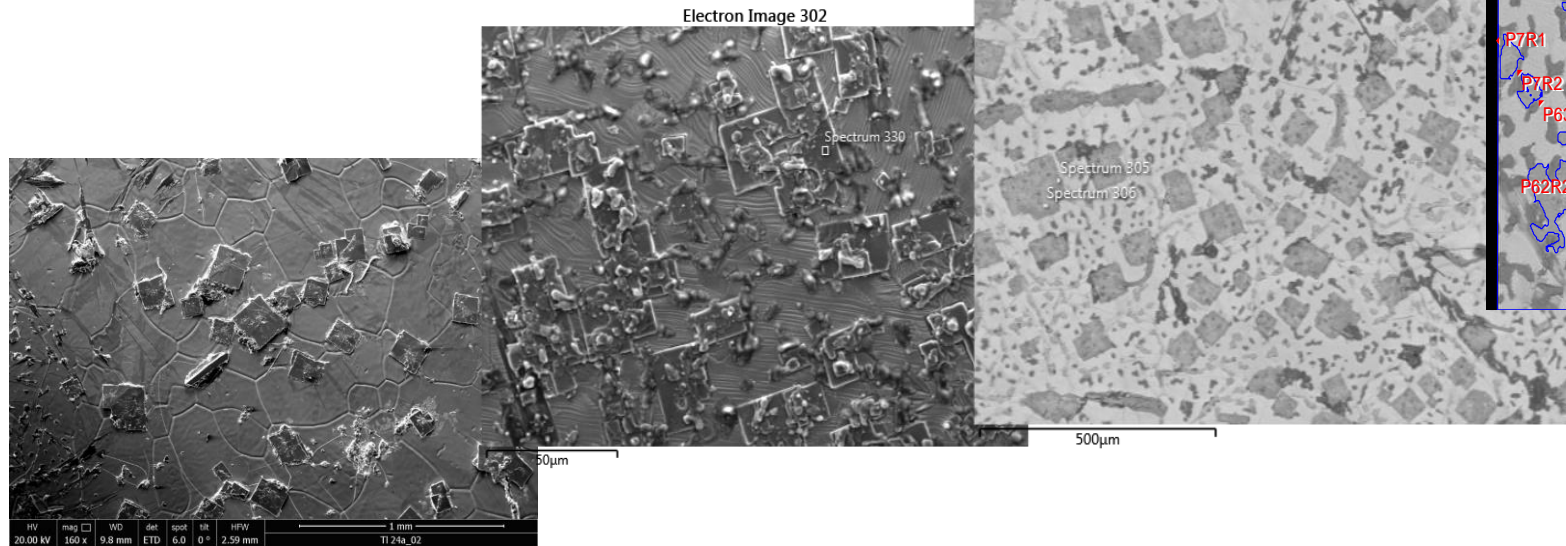
- High critical temperature
- High Birr
- High current density
- The electrochemical deposition on the substrate.
- Concave metal surface



Continuous potential deposition cause bubble and porosity



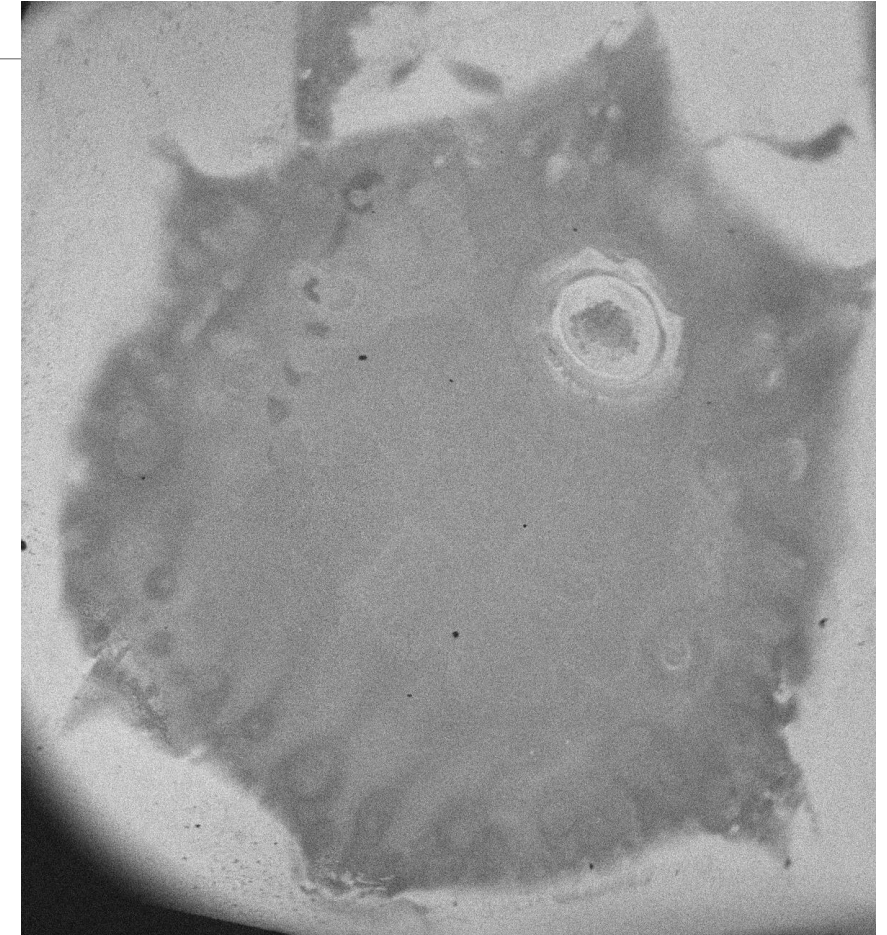
- Literature??
- Thallium vitality
- Electrodeposition method
- Advancement made on thin films (Coverage and right phase)



40 Percent coverage

Precursor's deposition and Formation of the bubbles

- Minimization of Bubble formation
 - ✓ N2 purged
 - ✓ Stirring
 - ✓ Pulse deposition
- Improved thickness
 - ✓ Reduction of bubbles
 - ✓ Less porous
 - ✓ Treatment of the film with non reacted pellet



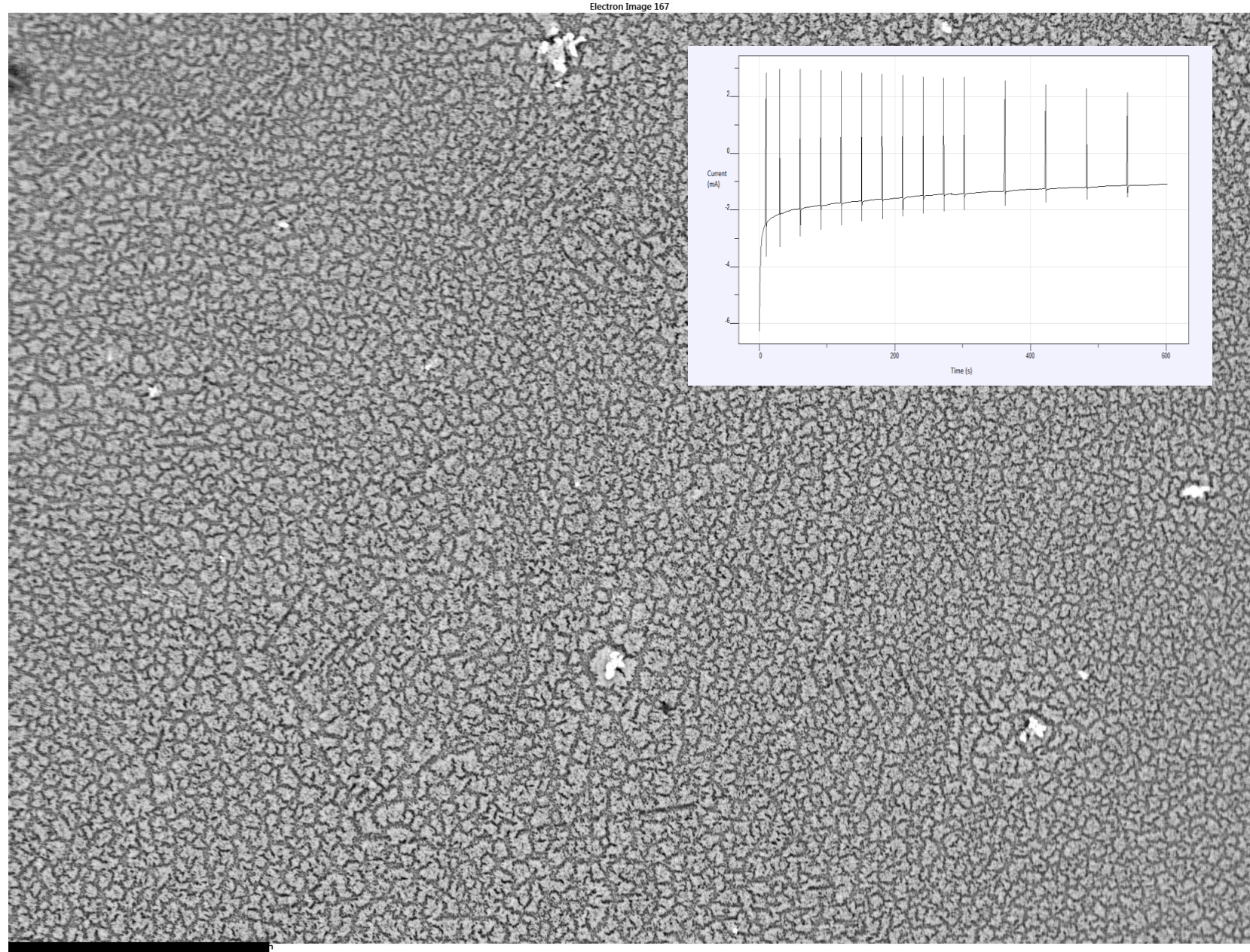
*Voltage should be below -1.2 V to avoid bubble formation

Pulse deposition

Deposition at -3 V and pause after every 30 seconds for 0.2 second

Improvements

- Homogeneous
- Well covered
- No bubble



100 μm



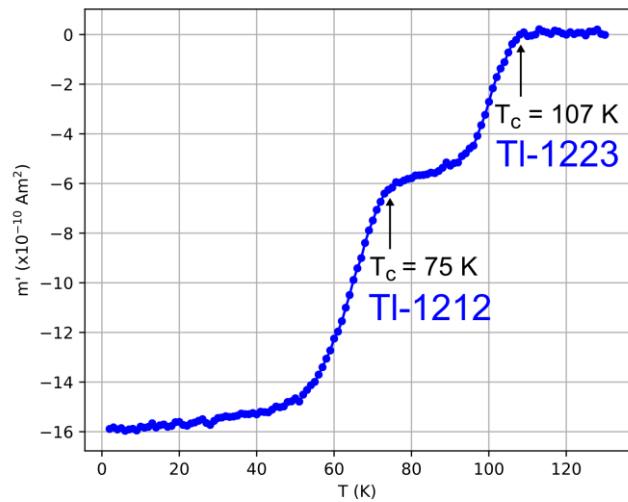
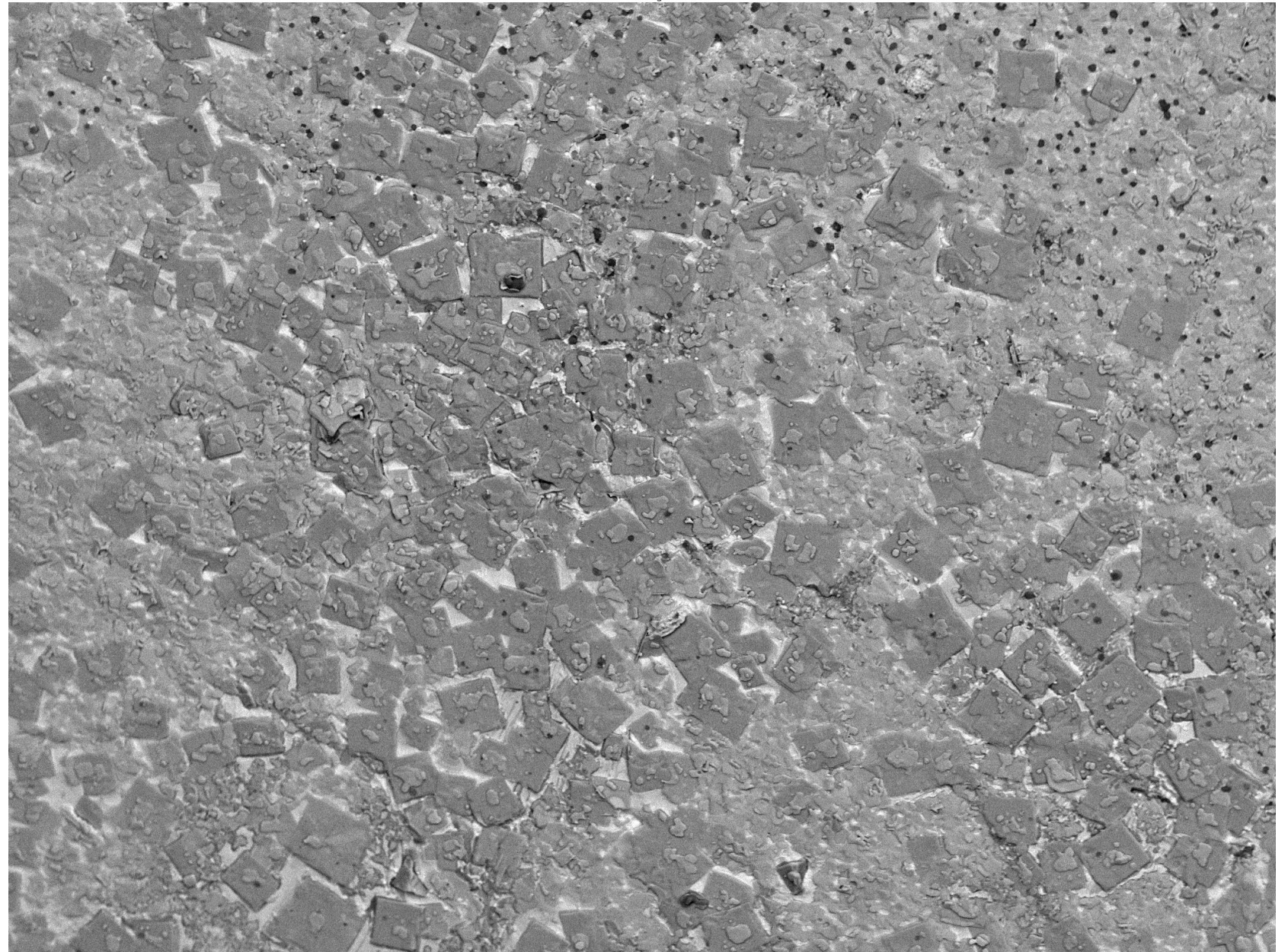


- Cylindrical, triangular and packet Gold capsules to minimize the thallium lose
- Heat treatment with fire or unfired thallium 1223 pellet

A SEM image of Tl-based thin film

Quite covered thin film

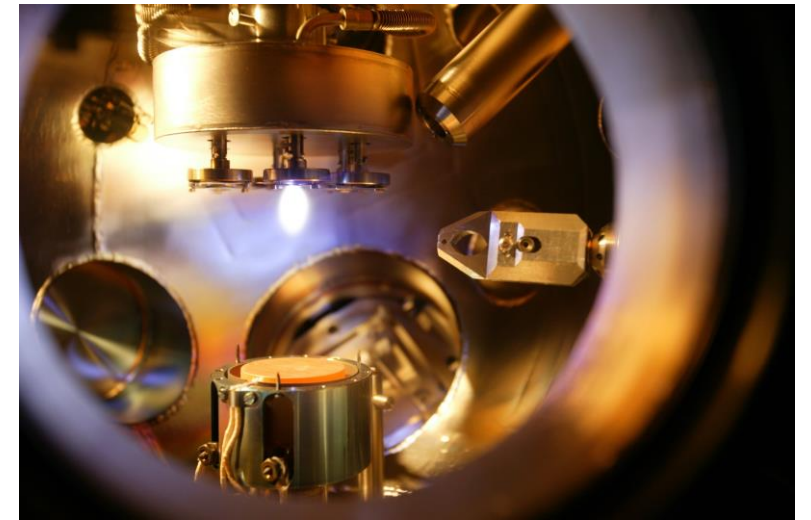
Combination of 1223 and 1212 phase



100 μm

Pulsed Laser Deposition on Silver, STO and LAO substrates using Tl-1223 Pellet

Deposition time	1 Hour
Frequency	5 Hz
Laser energy	240 mJ
Vacuum	1.56×10^{-7} mbar
O ₂ pressure	1.02×10^{-2} mbar
Distance between target and substrate	3-4 cm

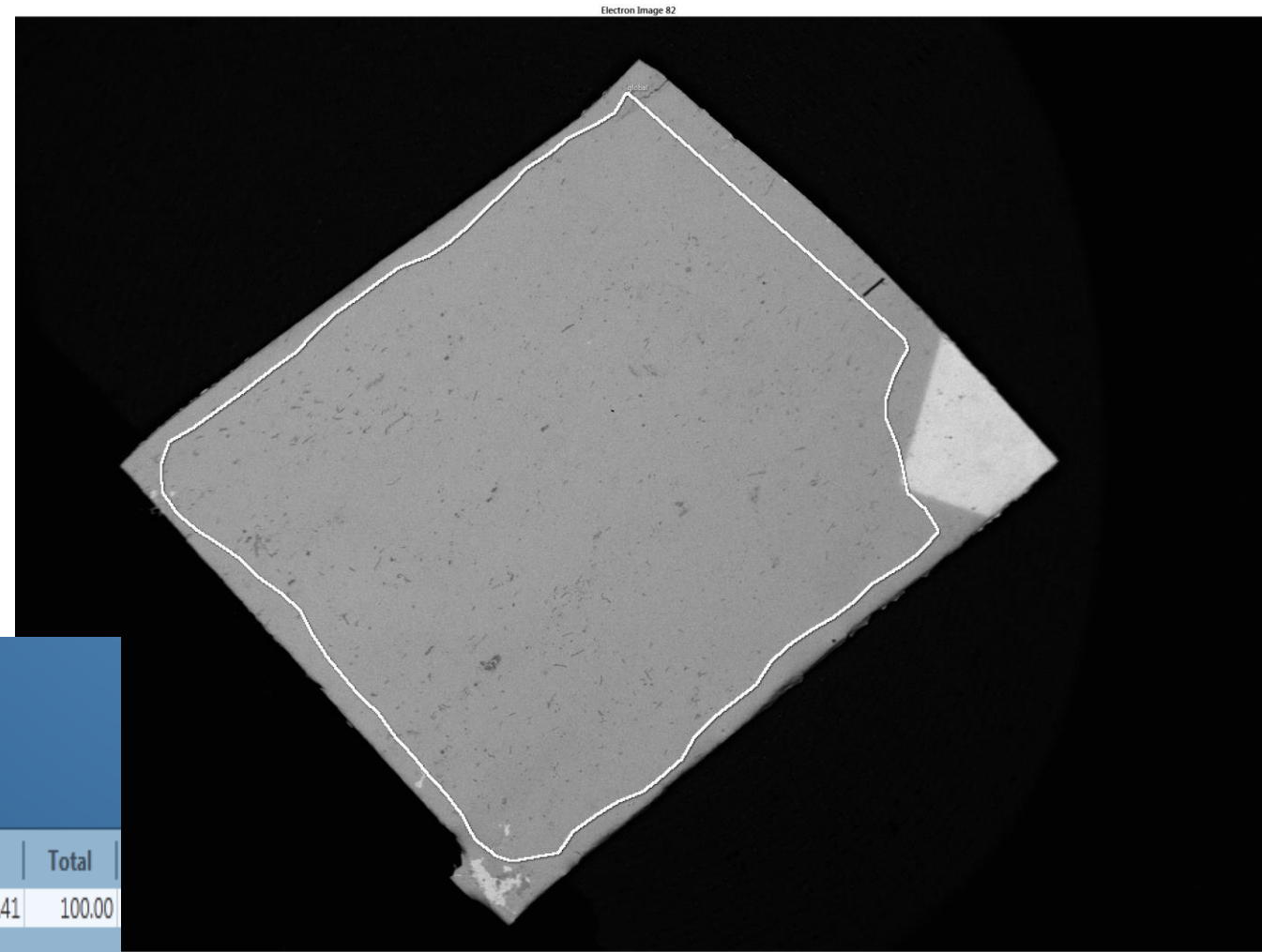


Substrate : Silver

Composition : 1223

Time: 60 minutes

O₂ pressure : 1.02×10^{-2} mbar



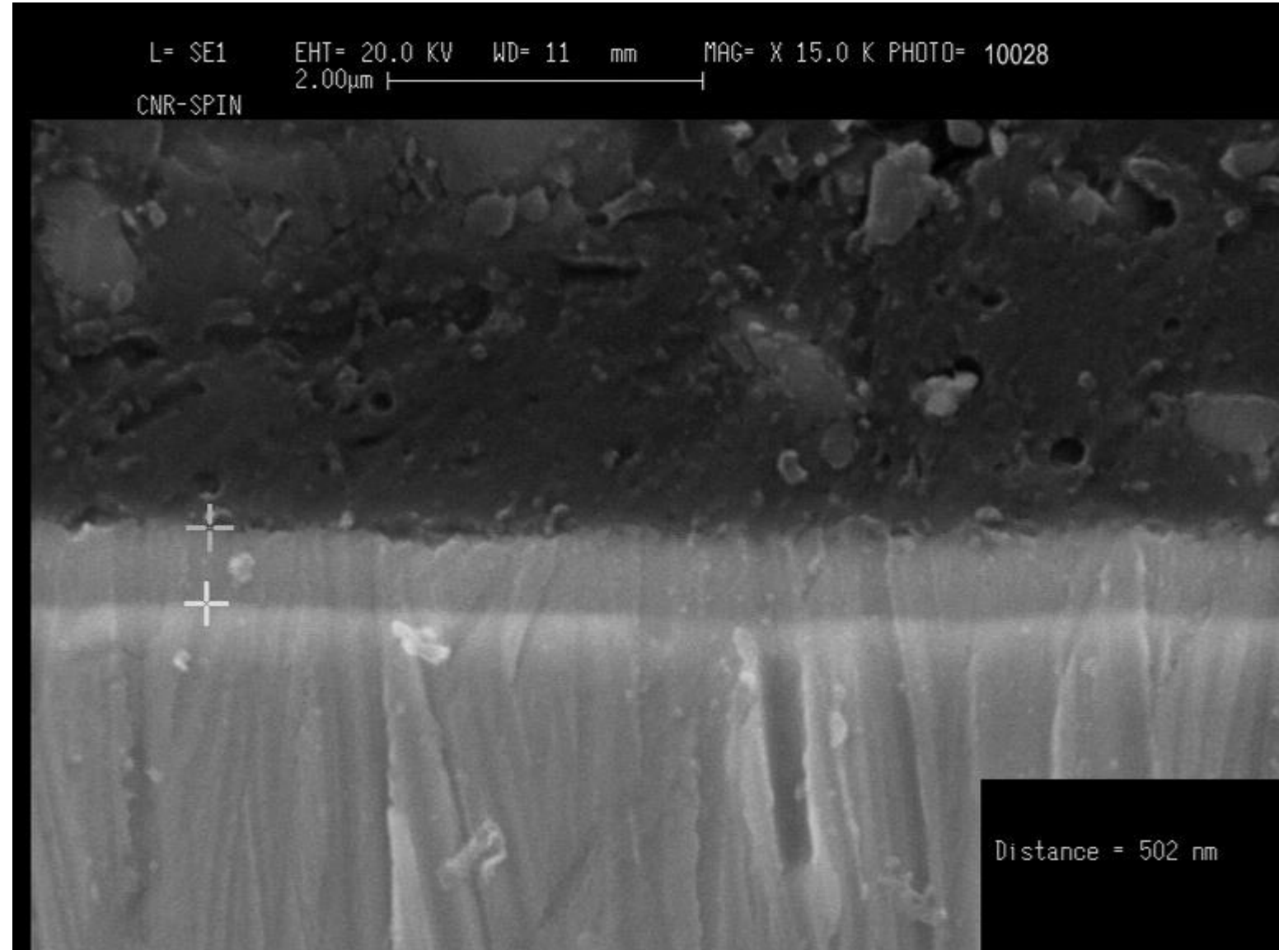
Quant Results View

Viewed Data: Multiple Spectra

Result Type: Atomic %

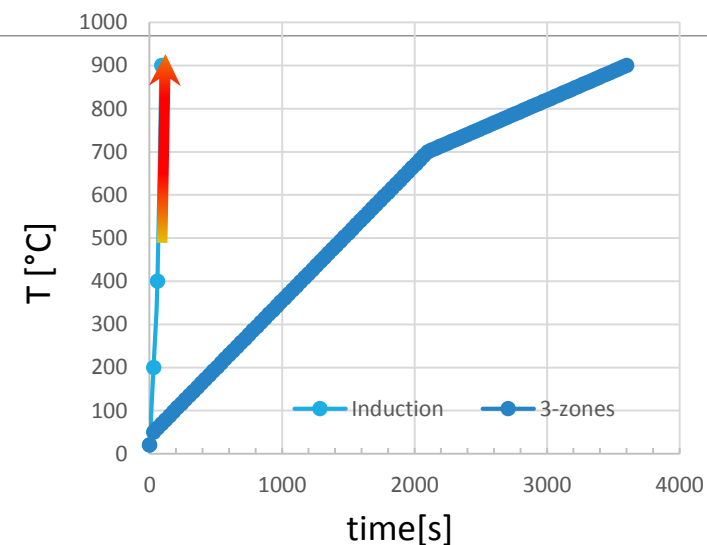
Spectrum Label	O	Ca	Cu	Sr	Ag	Ba	Tl	Pb	Bi	Total
global	64.98	4.57	6.24	4.01	17.66	0.93	0.89	0.32	0.41	100.00

- ✓ One hour deposition leads to 400-600 nm
- ✓ Right oxygen pressure helps to achieve 1223 stoichiometry
- ✓ Film deposited from ED are more porous
- ✓ PLD gives more densified precursor



Heat treatment techniques for PLD deposited samples

1. Tl oxide powder
2. Unreacted pellet
3. Reacted pellet
4. Quartz tube
5. Induction furnace

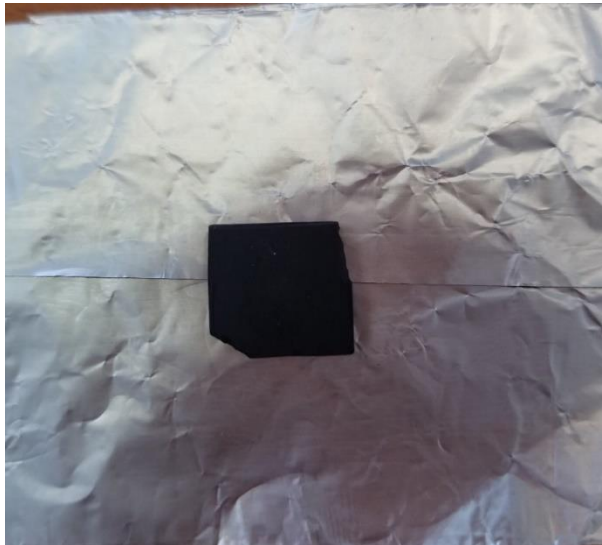


Are thallium-1223 superconductors vacuum compatible???

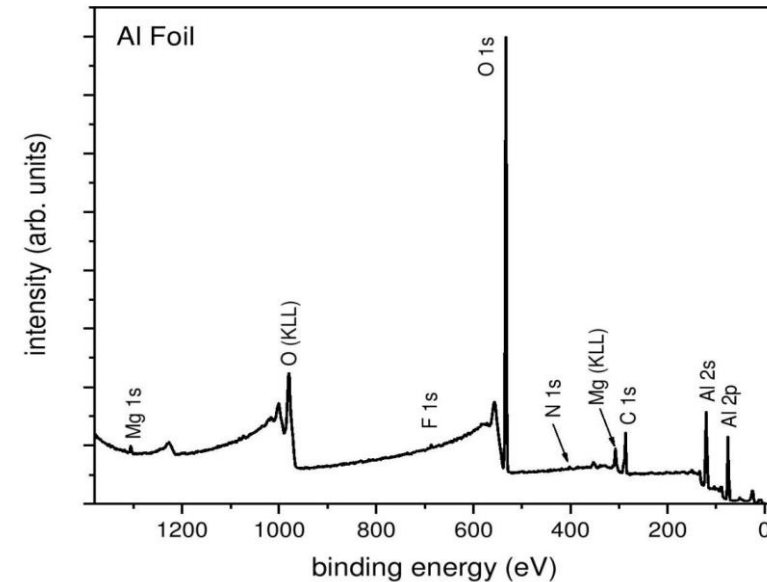
1. Pump down characterisation
2. XPS Characterisation
3. Secondary electron Yield

Vacuum Compatibility

Thallium samples containing heavy metals: **Tl, Pb, Bi**

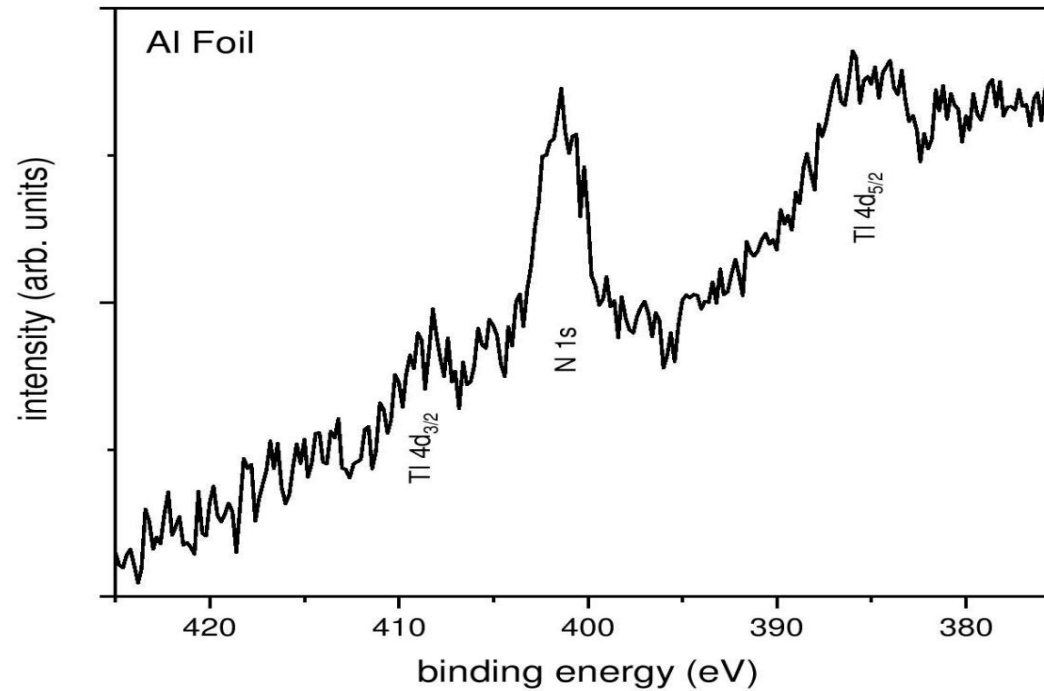


Tl-1223 phase pellet on the surface of the aluminium foil



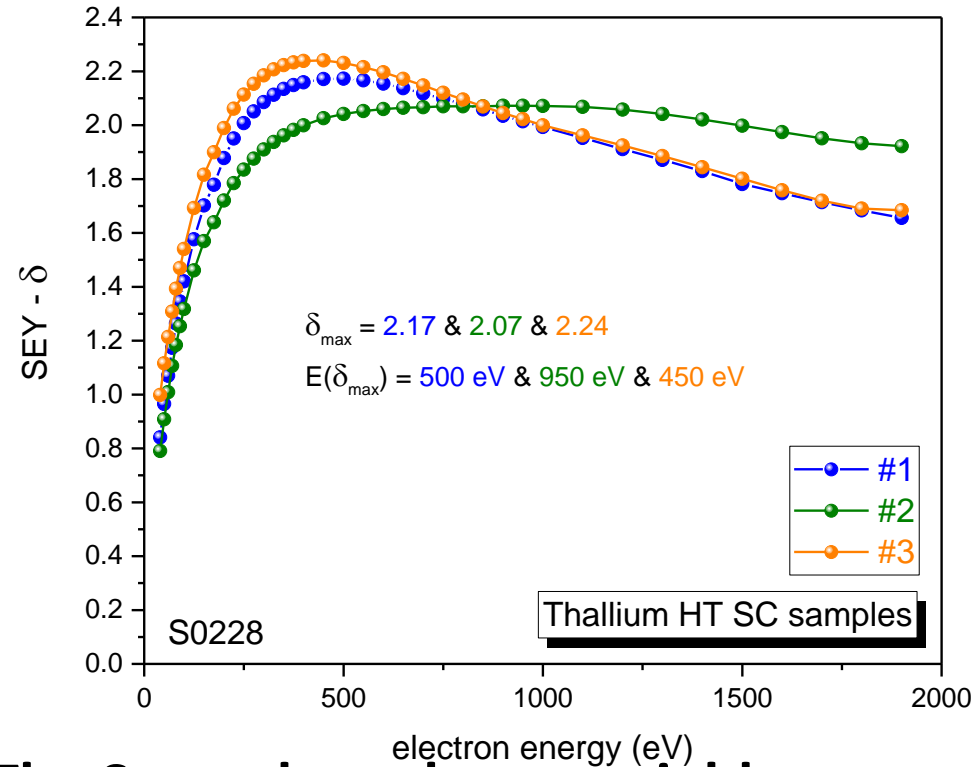
The XPS result of Aluminium foil touching the thallium-superconducting pellet does not show any trace of thallium.

Surface is Oxidized



- The estimated amount of detected **Tl is 0.1 at. % and hence very low.**
- After high-temperature annealing of the sample, the concentration of the thallium decreases

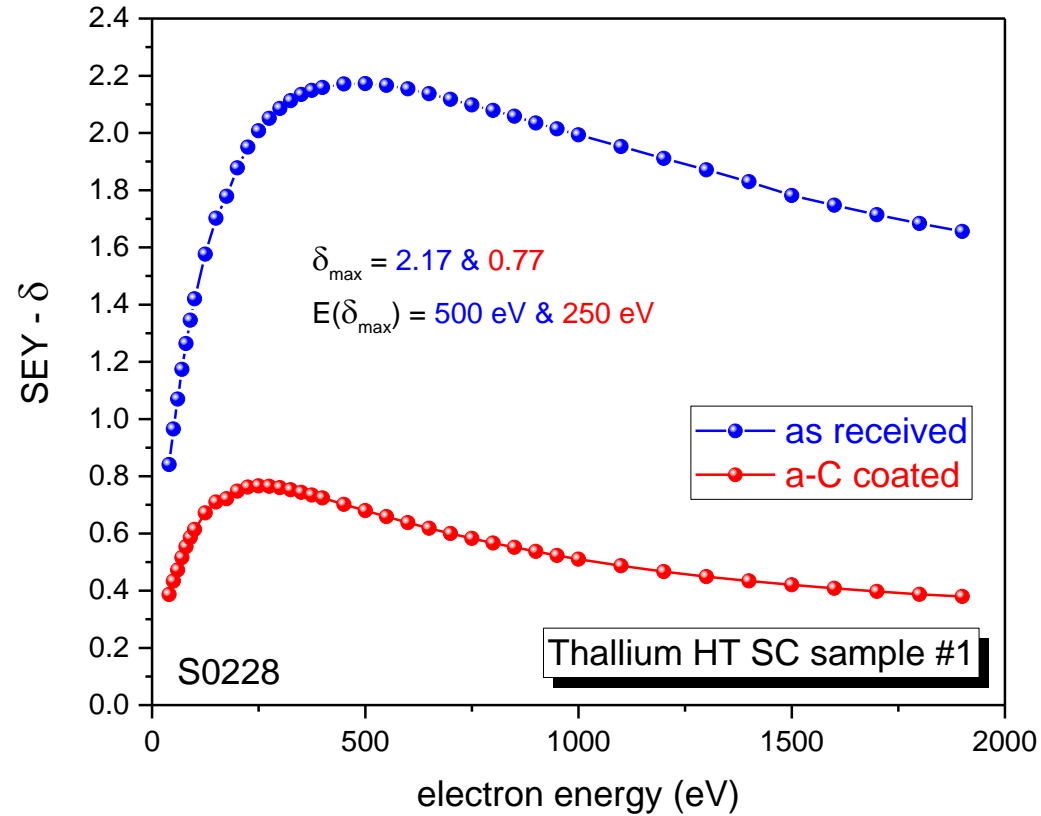
Secondary electron yield



The Secondary electron yield curves of the pellet before and after a-carbon coating.

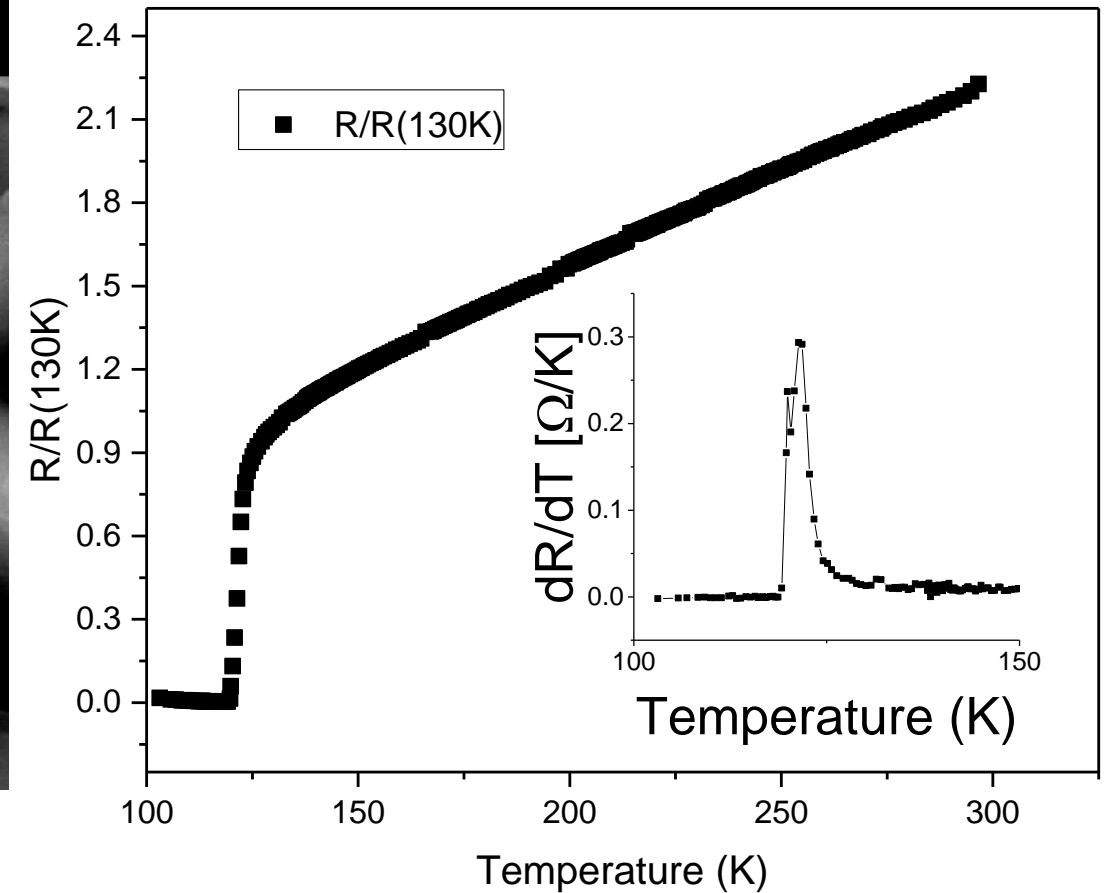
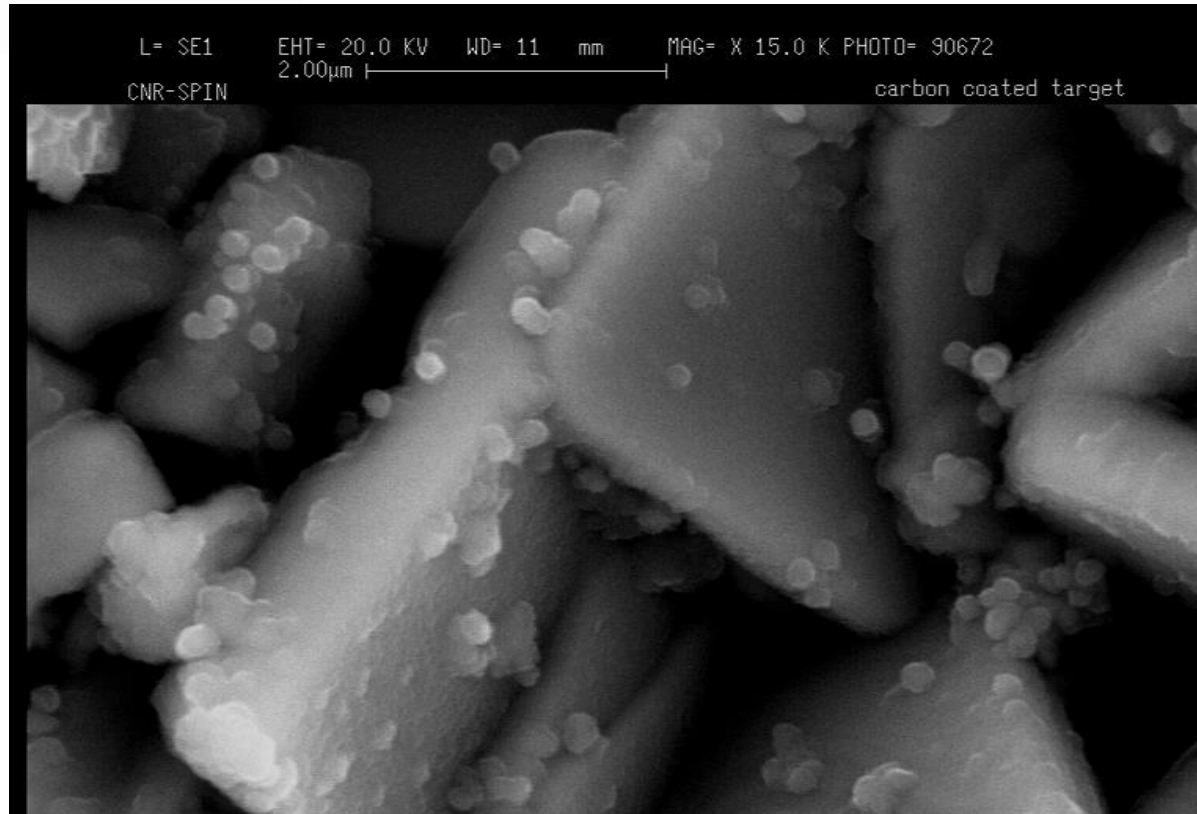
But the value of SEY must be less than **1.3** to prevent the formation of an e-cloud

SEY measurements for bulk sample



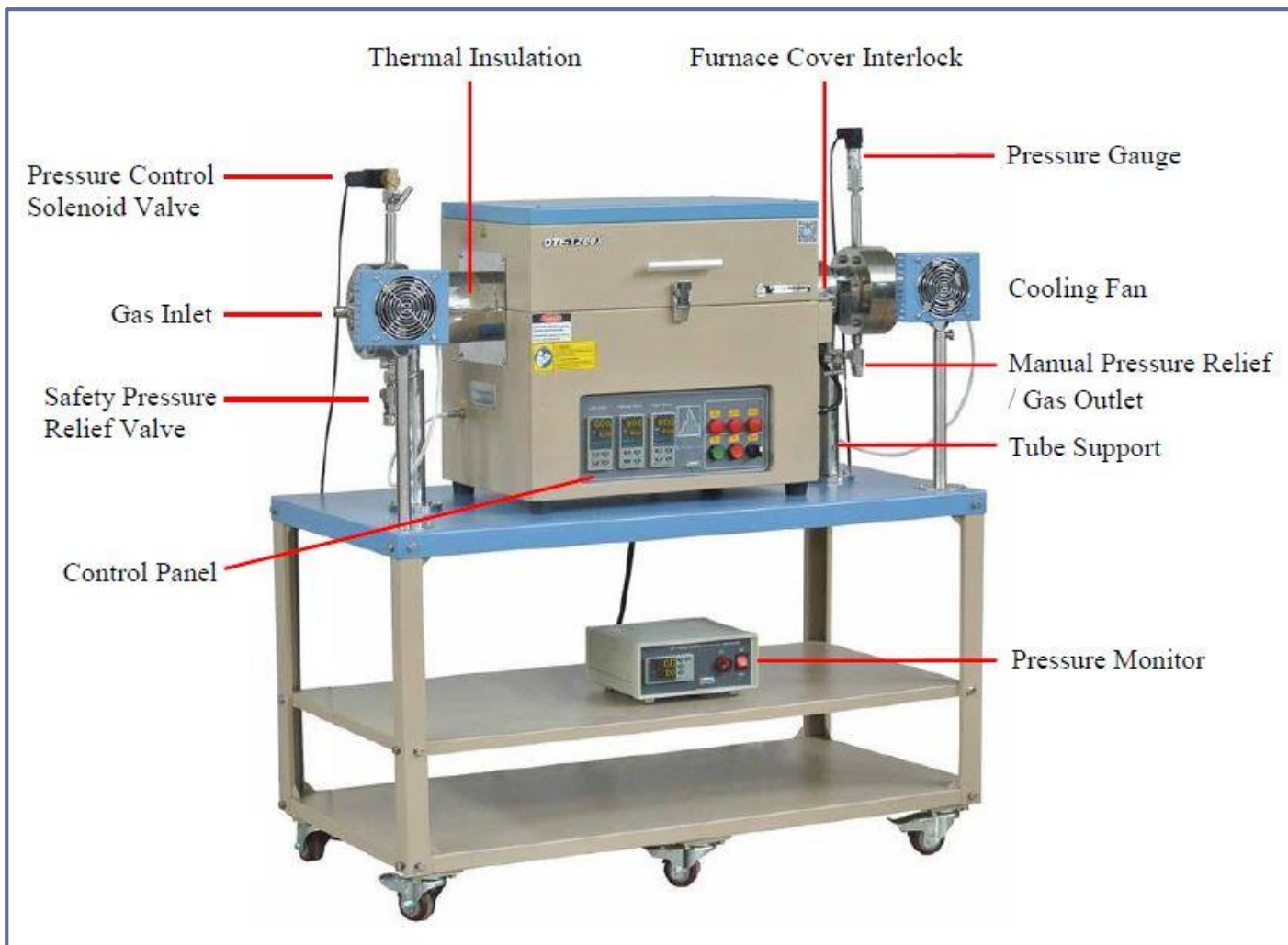
Remarkably reduces to **0.77** from 2.17
 Even less than Copper (~ 0.8)

Carbon coated pellet has T_c of about 121 K



New Synthesis approach

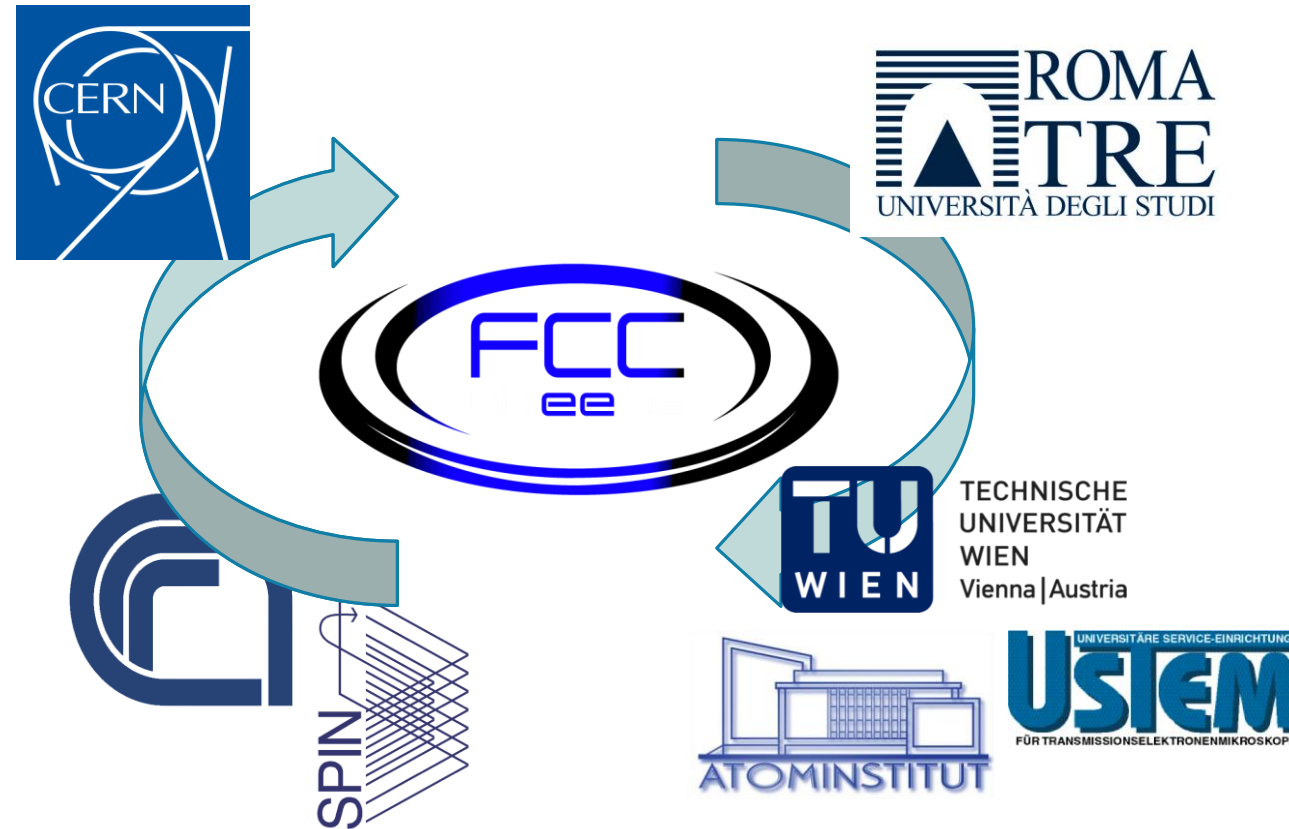
200 bar Max. at 650 °C
140 bar Max. at 800 °C
80 bar Max. at 900 °C
50bar Max. at 1000 °C
2.5 bar Max. at 1100 °C
1.2 Bar Max. at 1150 °C



Conclusion

- Superconducting thallium sample are being optimized for the beam screen and many techniques are being implemented for improvement.
- Primary characterization have shown that thallium samples have a high potential.
- Thallium samples are vacuum compatible.
- The value of the emission coefficient has dropped to 0.77 from 2.17 for bulk sample.
- The value of the emission coefficient has dropped to 0.97 from 2.71 for thin sample.





Thank you for your attention!

