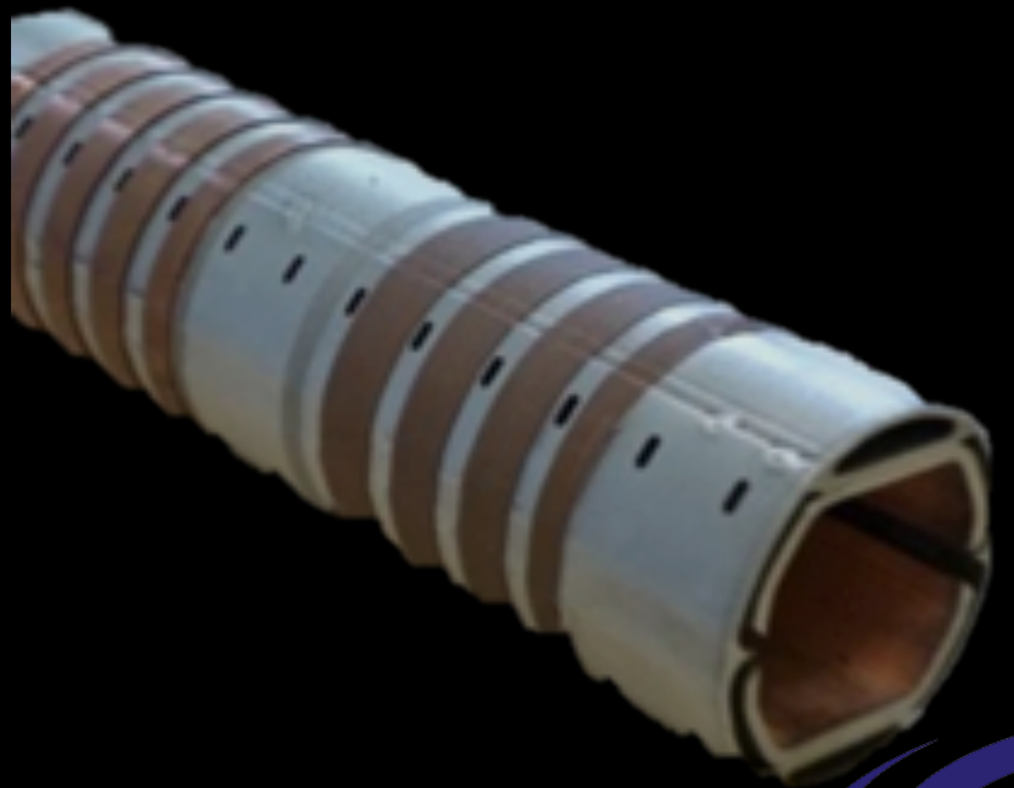
HTS Tl-based coatings for the FCC-hh beam screens

A. Leveratto
CNR-SPIN Genova

Amsterdam, 10th April 2018



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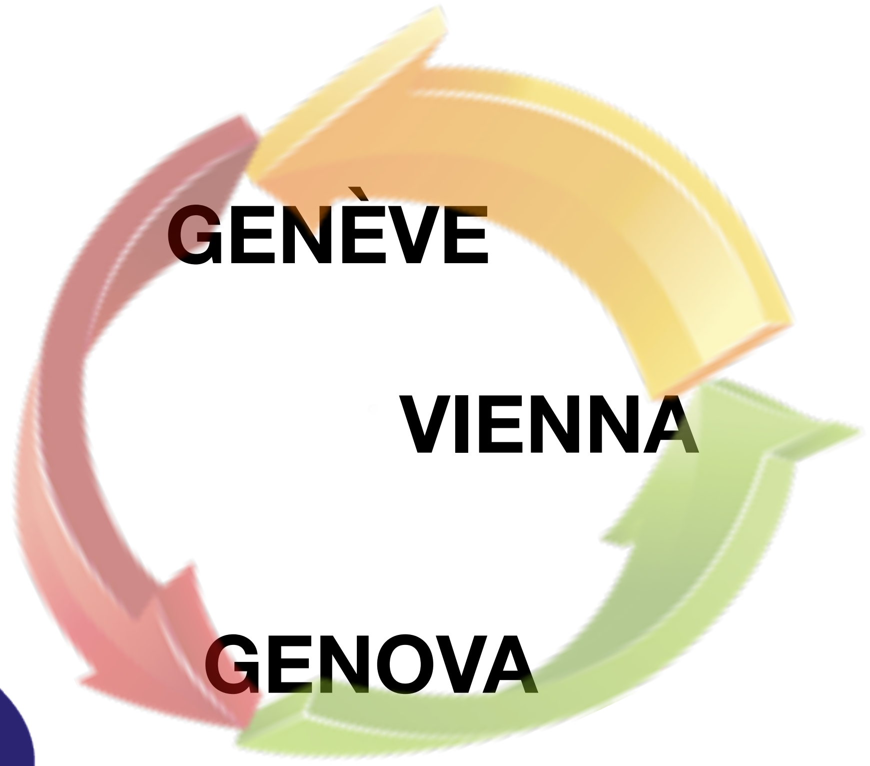
S. Calatroni

J.Bernardi

A. Moros EASItrain



M. Eisterer

S.Holleis

T. Baumgartner

E. Bellingeri

C. Ferdeghini

M. Putti

R. Vaglio

EASItrain A. Saba

Outline

- Project introduction
- Why HTS?
  - Surface impedance
  - HTS vs Copper
  - Why Thallium based?
- Sample preparation
- First Results
- Conclusions & Perspectives

Project introduction

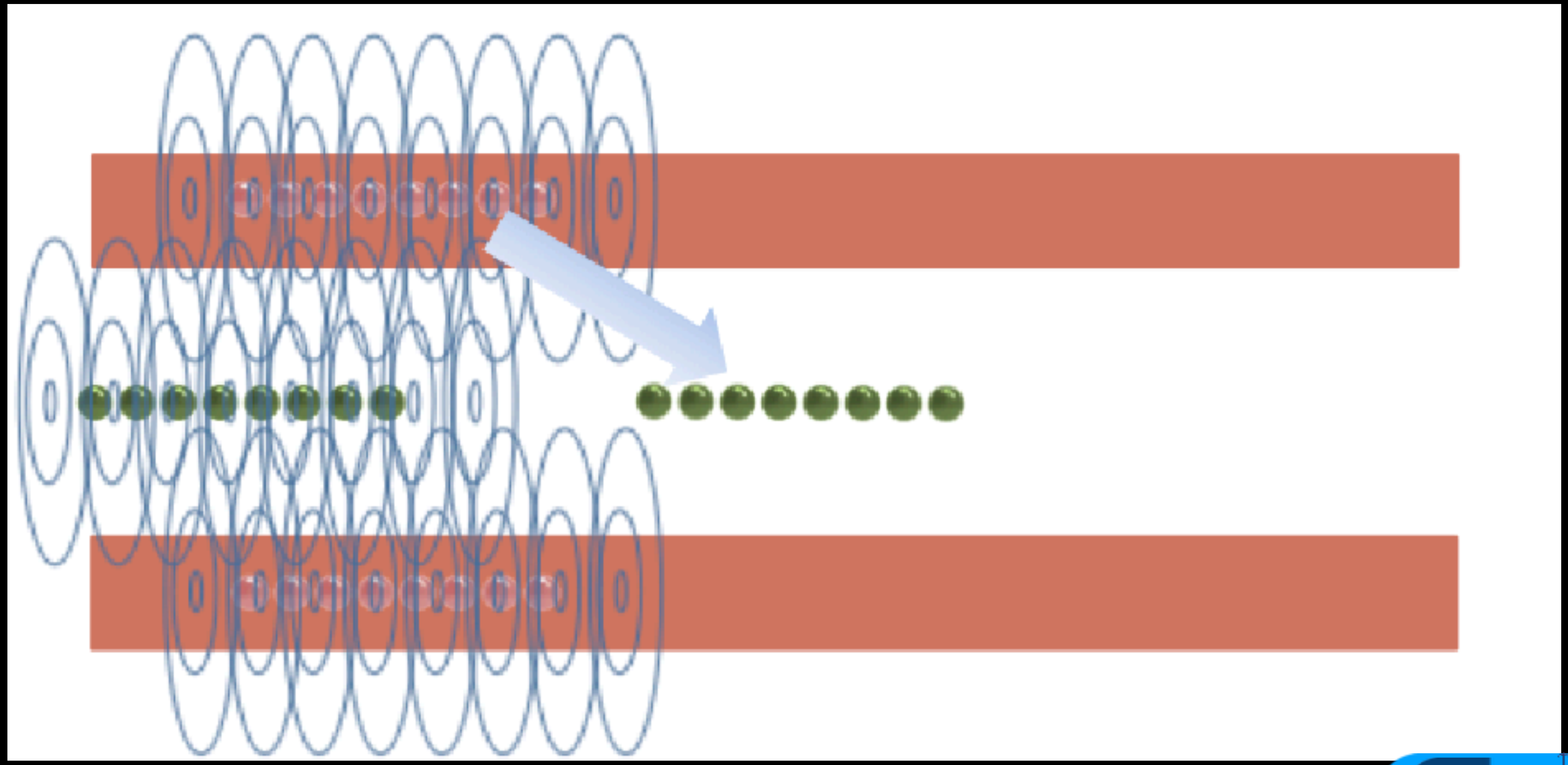
10^{11} protons will circulate in bunches in the ring at v≈c

Proton are charged -> it will produce an EM field

The EM Field will produce an image current in the screen

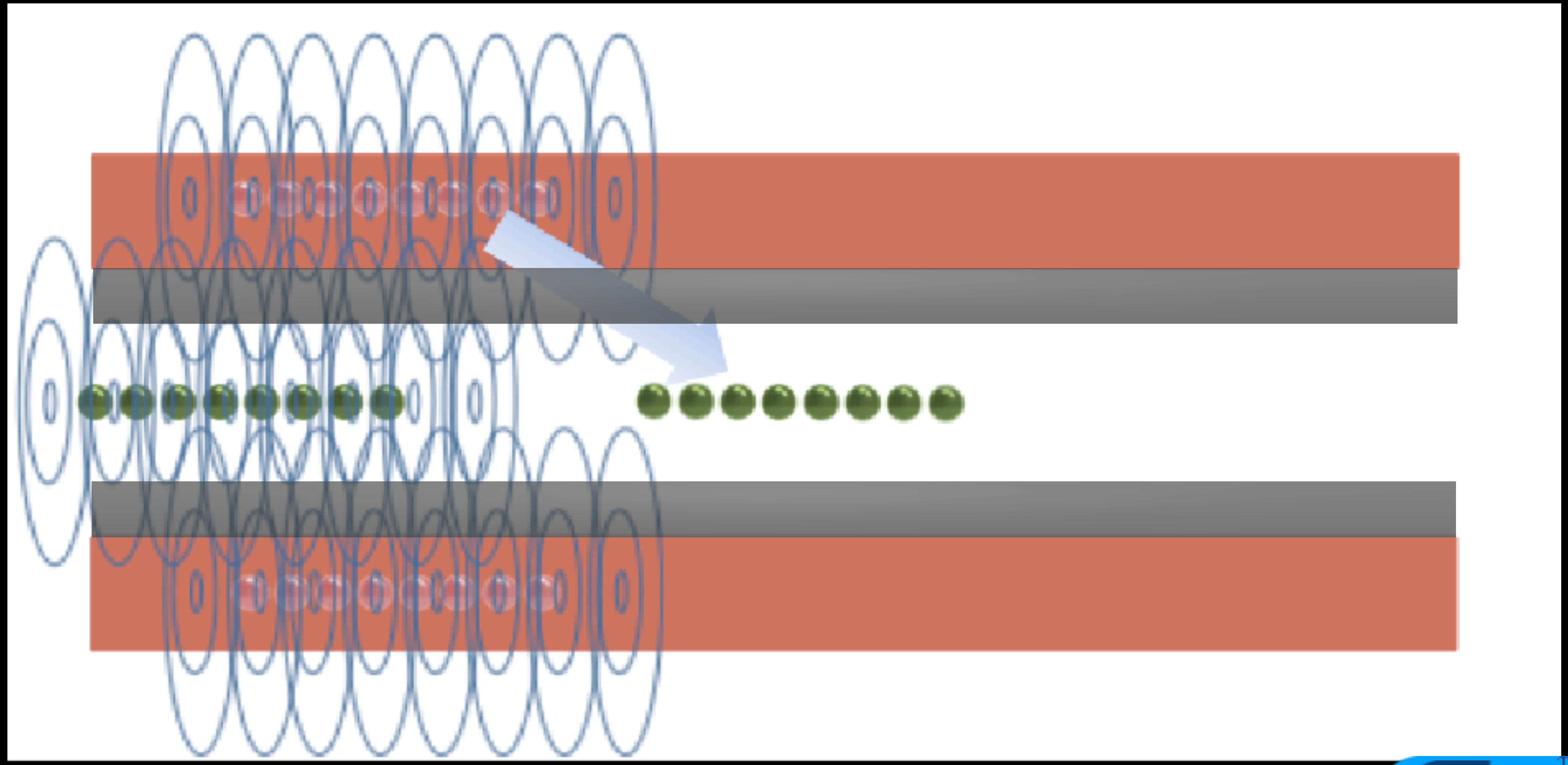
The image current will dissipate

Due to the delay, it will affect back the beam causing instabilities.



Project introduction

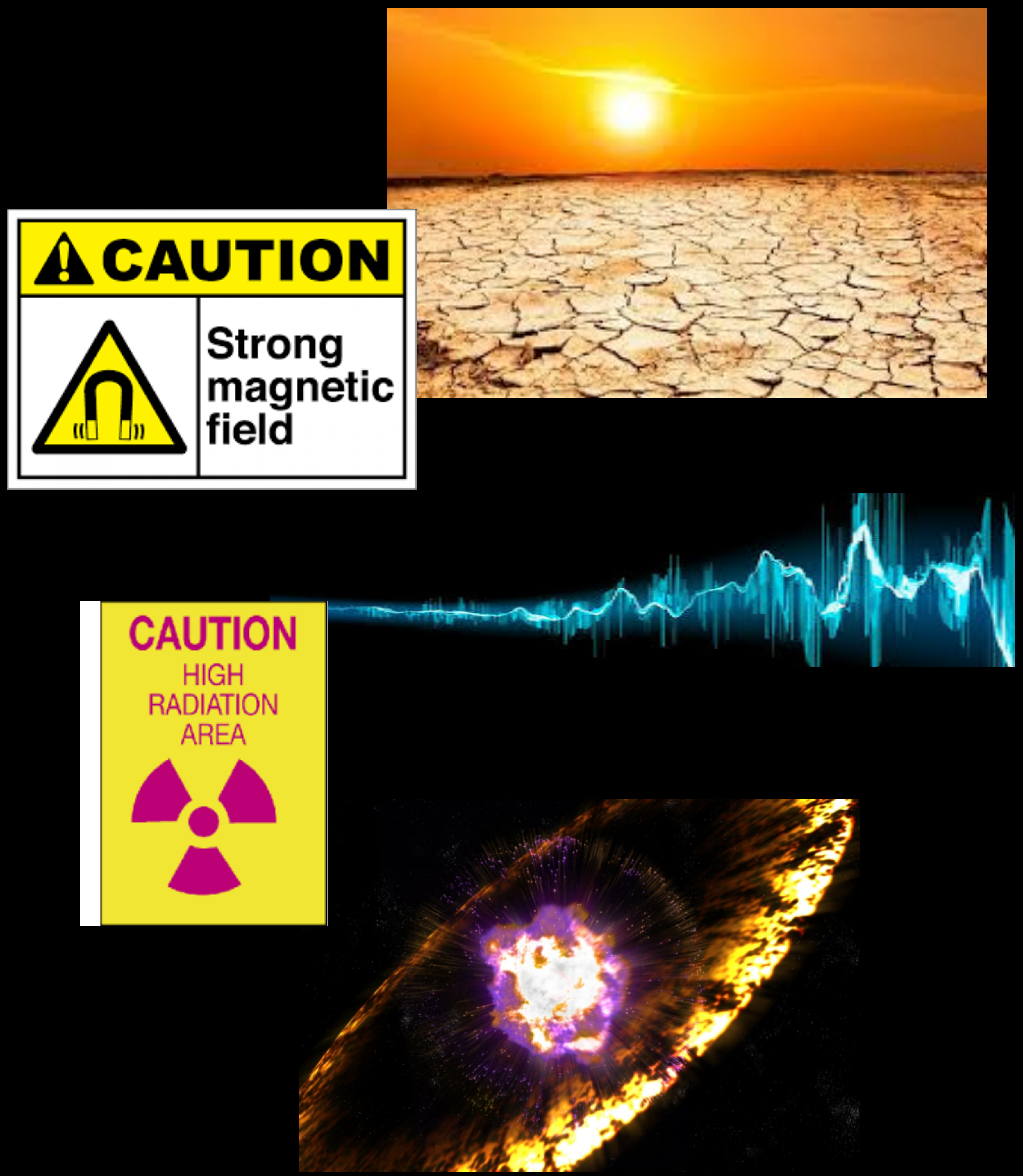
The surface resistance of copper at 50 K may not be sufficiently low to guarantee a safe operational margin for the FCC-hh beams (in particular at injection energy).



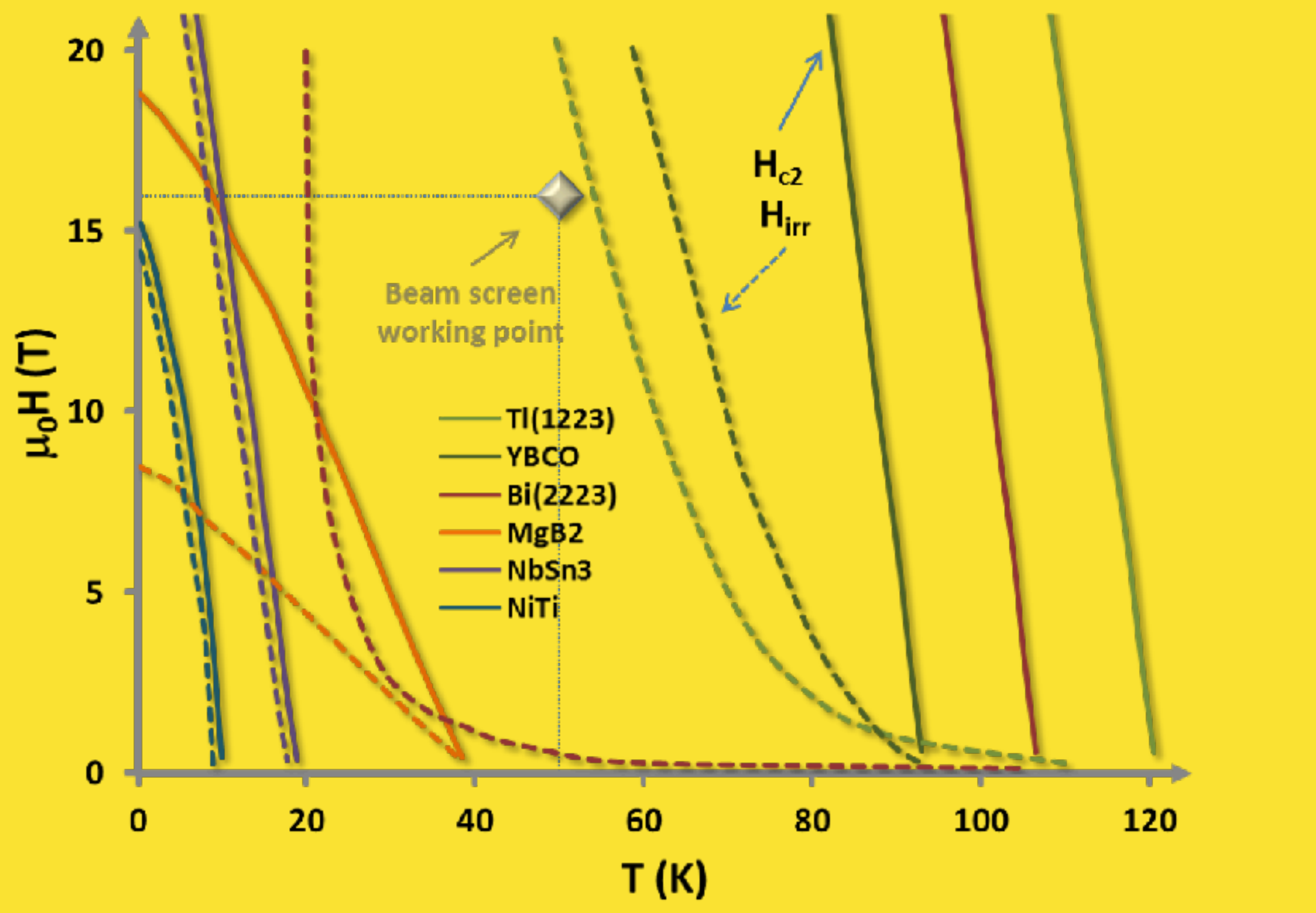
Why HTS?

HTS films requirements for beam screen

- T=50 K Very high operation temperature
- B=16 T Very High magnetic field
- f=1GHz Very high frequency
- High synchrotron radiation intensity
- Boundary materials with 100 TeV particles (only supernova burst can exceed this energy)



Why HTS? Surface impedance



	YBCO	Tl-1223
PROs	• Safe • Very high Jc • Very high steep Hirr	• High Tc • High Jc • High Hirr • Very tolerant for out stoichiometry • Ag substrate
CONs	• Strong weak link problems • Low Tc • Very expensive and complex preparation on large scale (IBAD,..)	• Toxic • Weak link?

$$\sqrt{\frac{H}{H_{c2}}} = \sqrt{\frac{16T}{80T}} = 0.45$$

$$\sqrt{\frac{H}{H_{c2}}} = \sqrt{\frac{16T}{140T}} = 0.34$$

$$Z_{sf} \equiv Z_f = Z_n \sqrt{\frac{B_0}{B_{c2}}} \qquad \text{for } \nu \gg \nu_0$$

$$R_{sf} \equiv R_f = \frac{R_n}{\sqrt{2}} \sqrt{\frac{B_0}{B_{c2}}} \left(\frac{\nu}{\nu_0}\right)^{3/2},$$

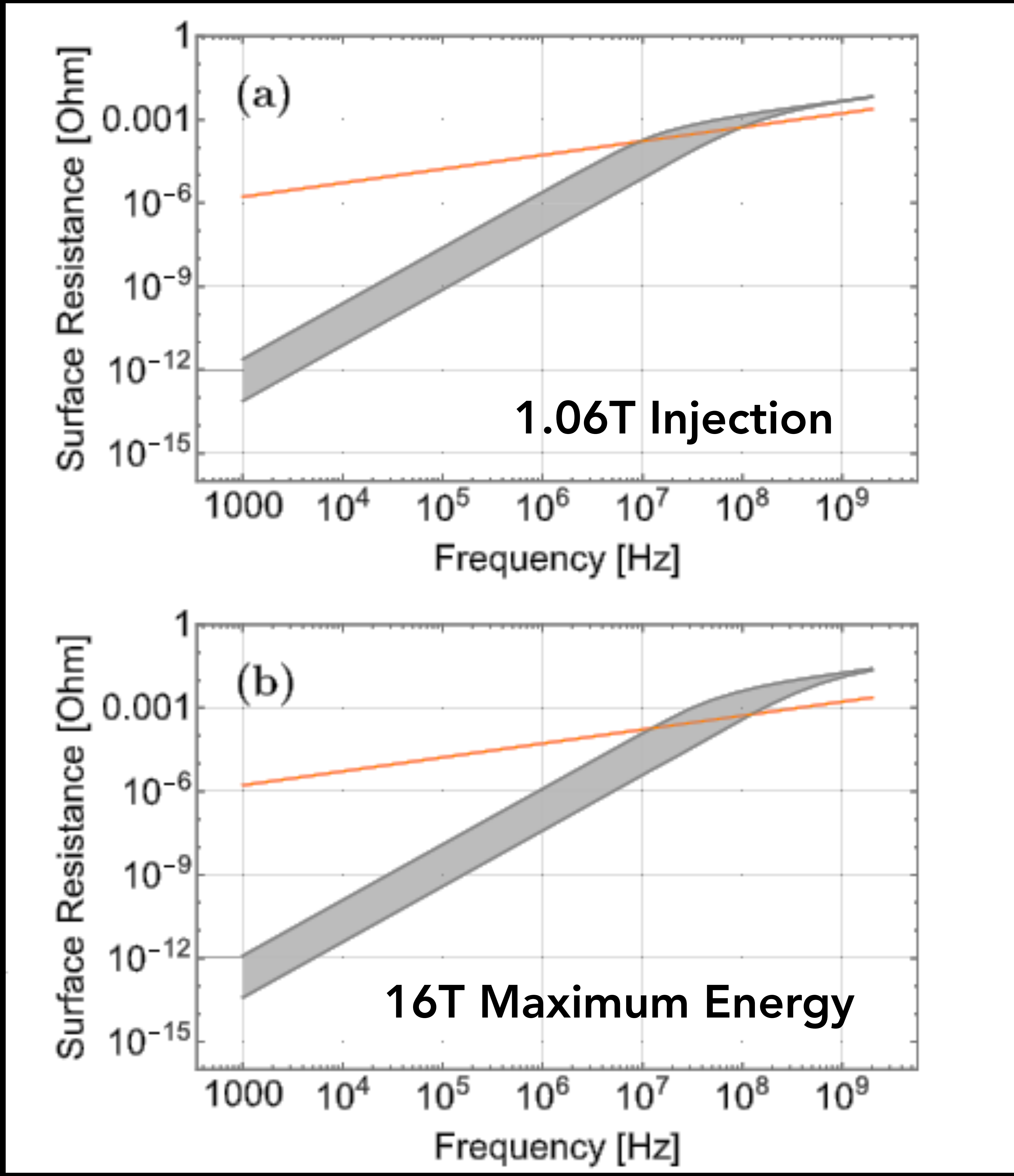
$$X_{sf} \equiv X_f = R_n \sqrt{2} \sqrt{\frac{B_0}{B_{c2}}} \left(\frac{\nu}{\nu_0}\right)^{1/2} \qquad \text{for } \nu \ll \nu_0$$

S. Calatroni and R. Vaglio, IEEE-TAS 7, 3500506 (2017)

$$Z_{sf} = Z_n \sqrt{\frac{H}{H_{c2}}}$$

Joffre Gutiérrez Royo
ICMAB

Why HTS? HTS vs copper



Depinning frequency > *rigid-fluxon* model

S. Calatroni, et al. 2017 SUST **30** 075002

Assuming:

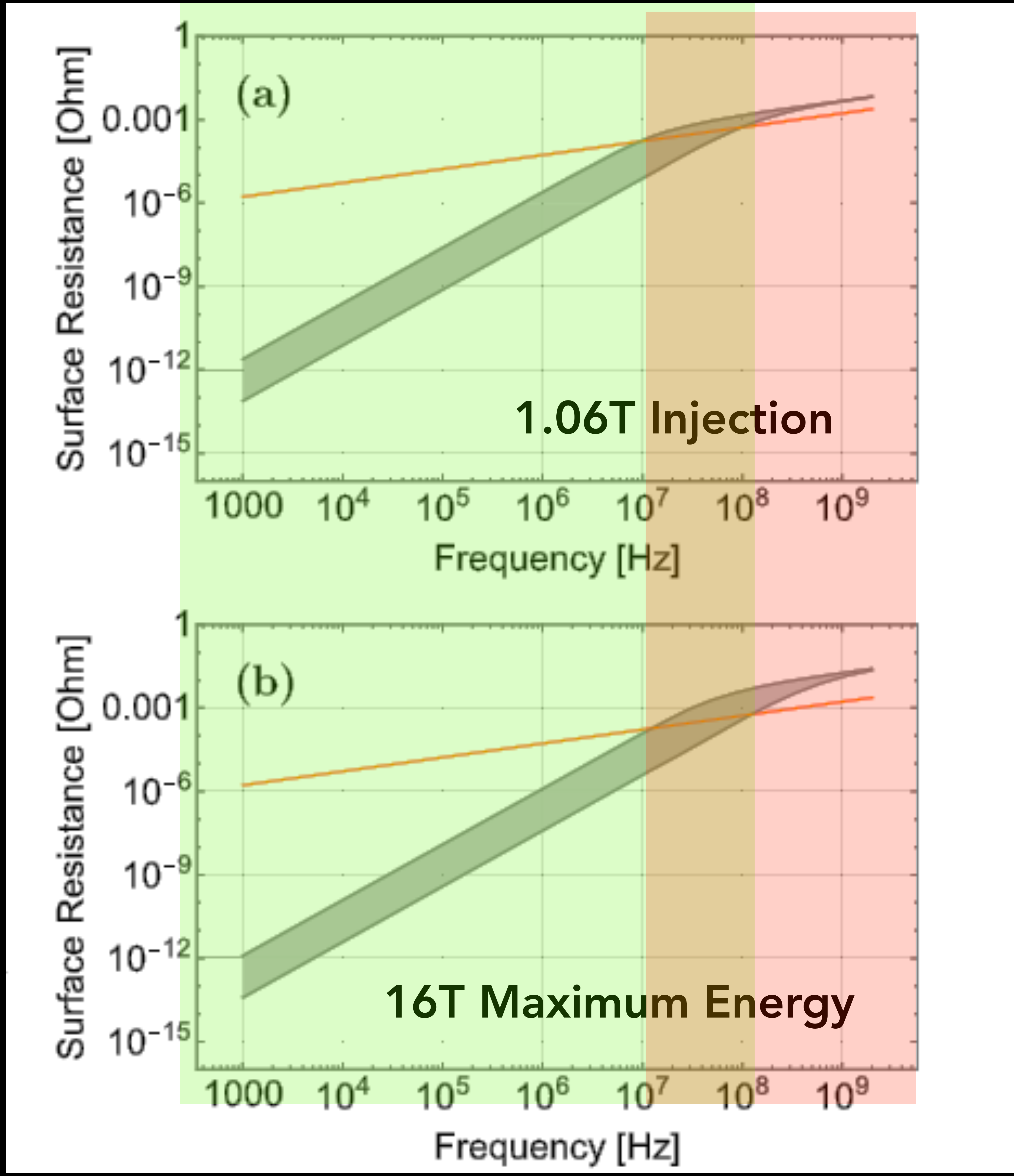
(conservative estimate)

ρ_n = 40 μΩcm

B_{c2} (50K) = 70T

$J_c \sim 10^8$ to 10^9 A/m^2

Why HTS? HTS vs copper



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At low frequencies, where the most unstable modes are predicted for a copper beam screen, a substantial gain of several orders of magnitude is clearly apparent

Why HTS? Why Thallium based?

IT WEARS QUITE WELL ALL THE REQUIREMENTS

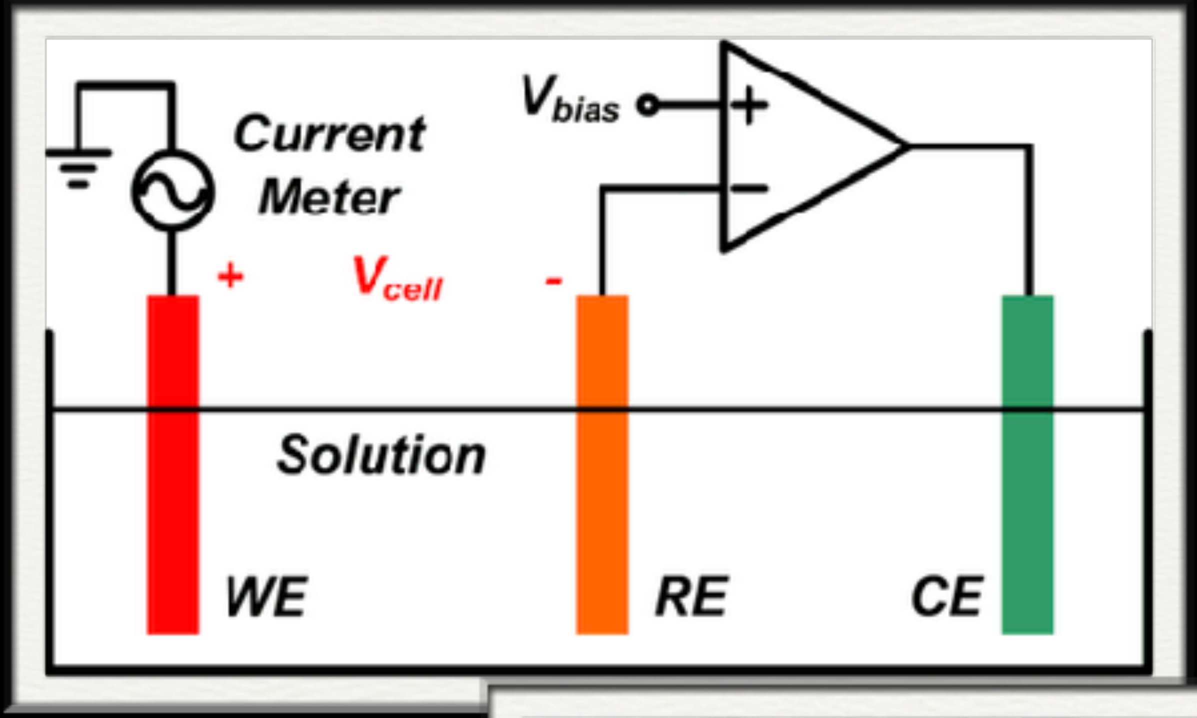
thanks to the electrochemical deposition coatings

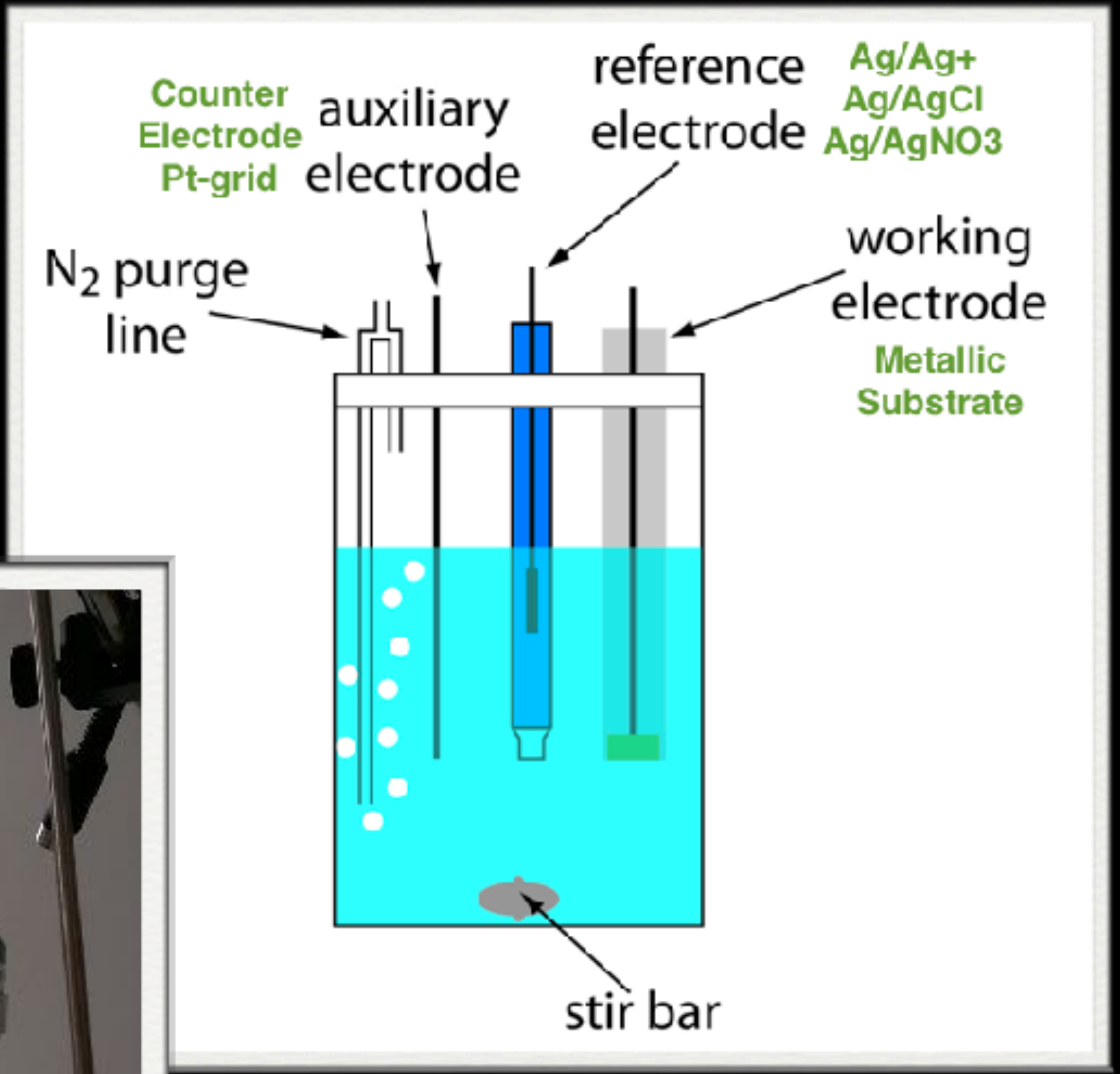
ONCE WE GOT THE “RECIPE”…

Large scale production could be achievable

Sample preparation

1st standard approach





Vertical Cell

$TlNO_3$ +

$Bi(NO_3)_3 \cdot 5H2O$ +

$Sr(NO_3)_2$ +

$Ba(NO_3)_2$ +

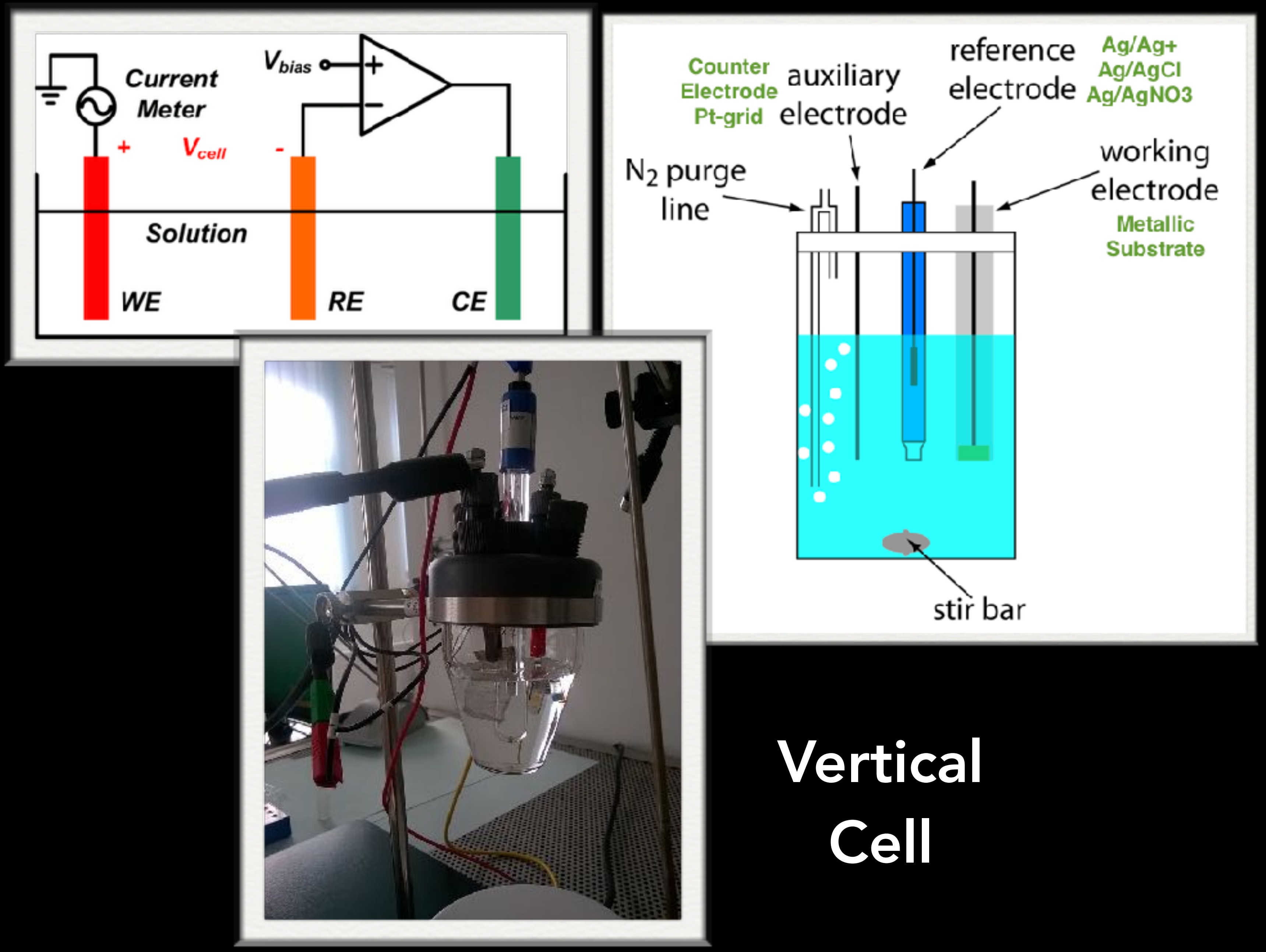
$CaNO_3 \cdot H2O$ +

$Cu(NO_3)_2 \cdot xH2\ O$

in dimethyl sulfoxide (DMSO), SigmaAldrich, 99.9%

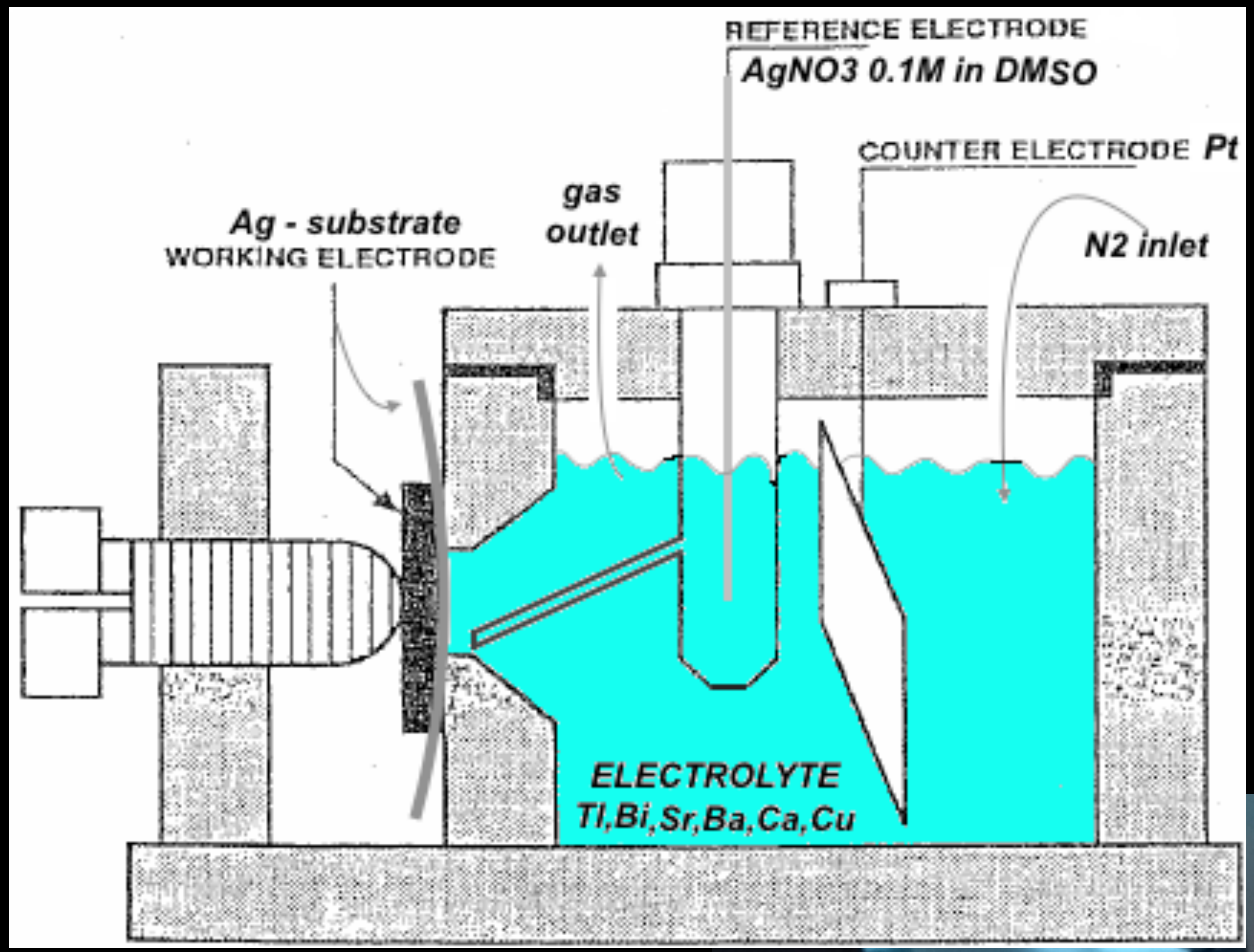
Sample preparation

1st standard approach

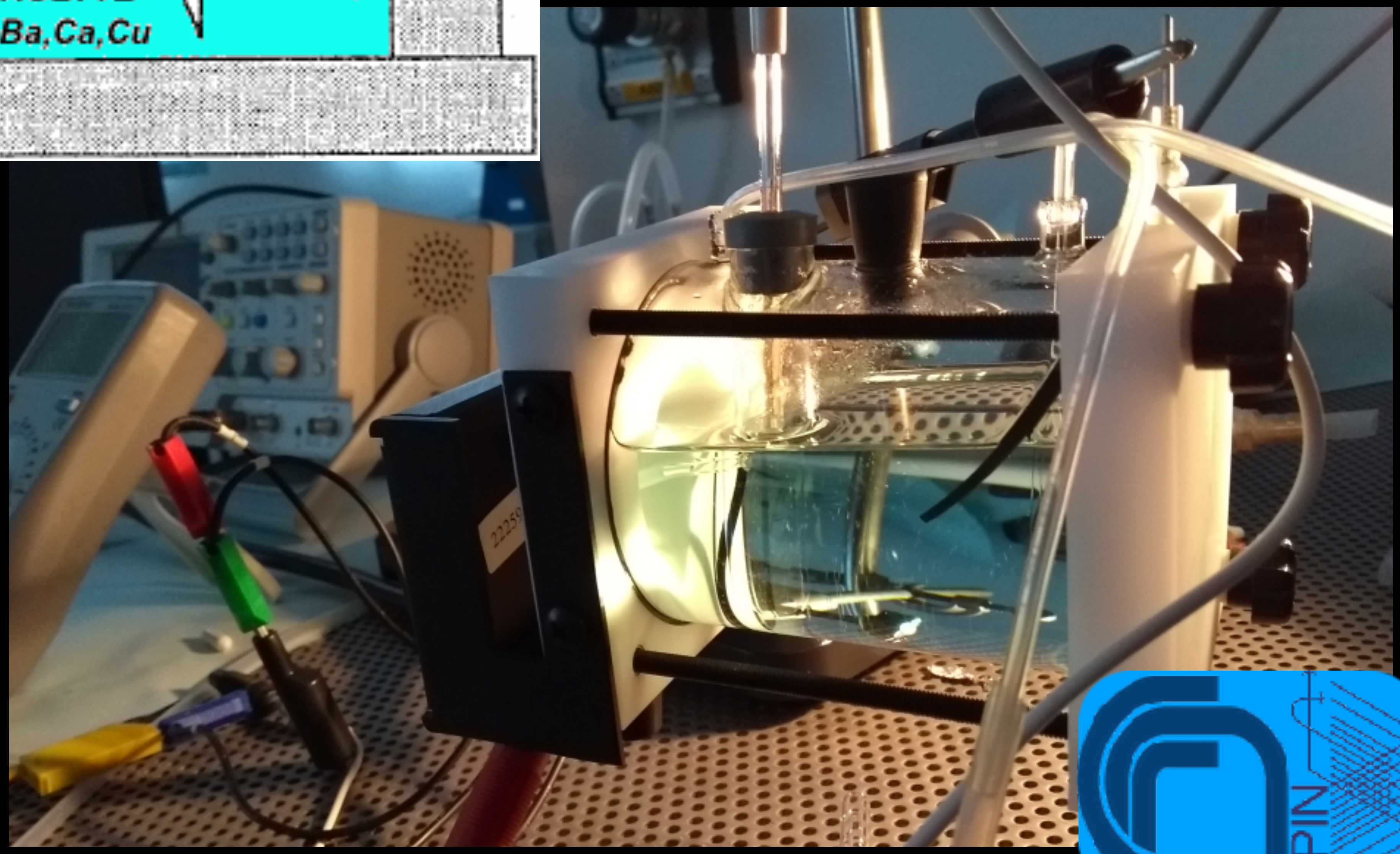


Vertical
Cell

2nd
approach

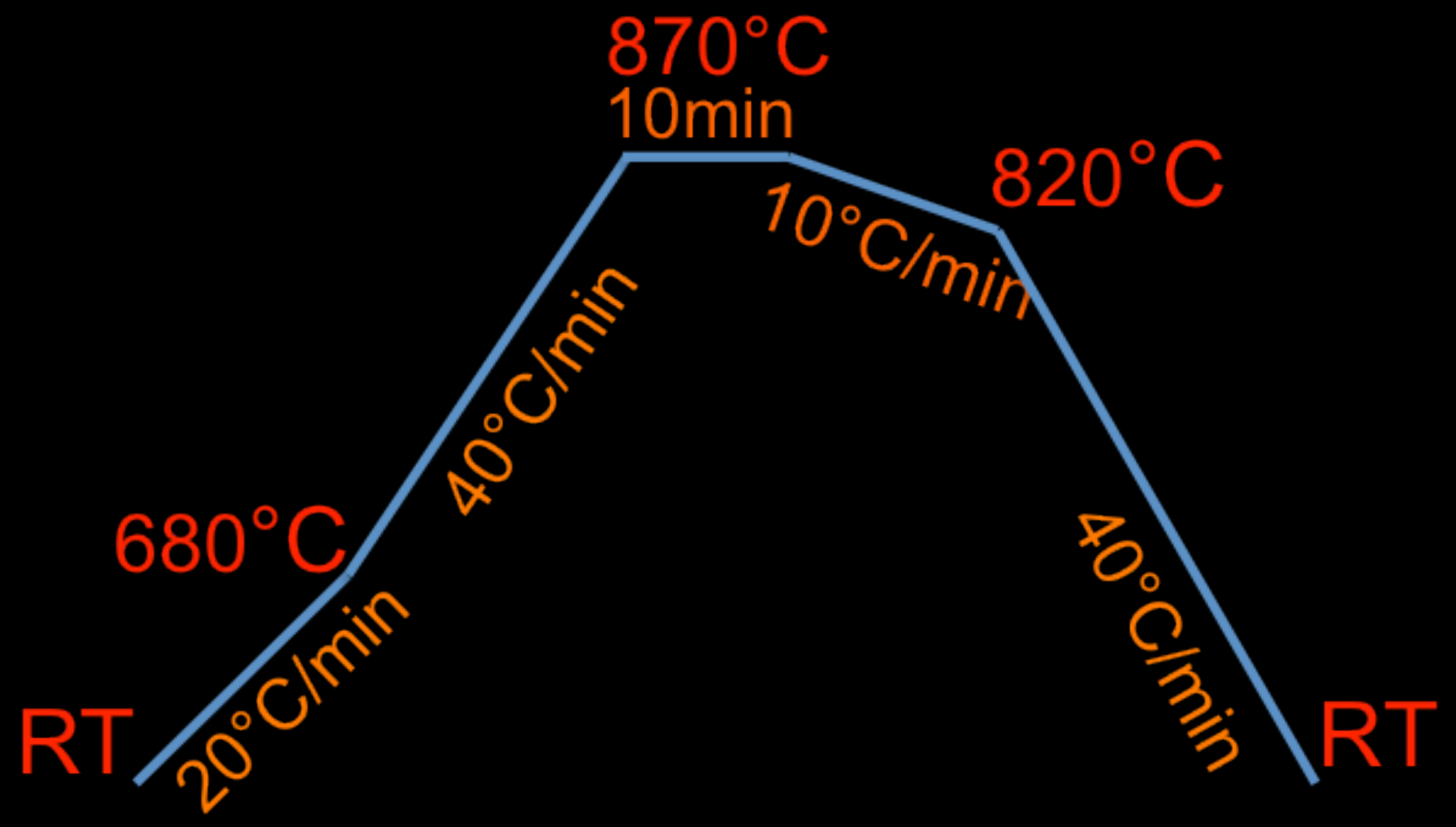


Flat
Cell



Sample preparation

Heat treatment 1bar/pure O_2



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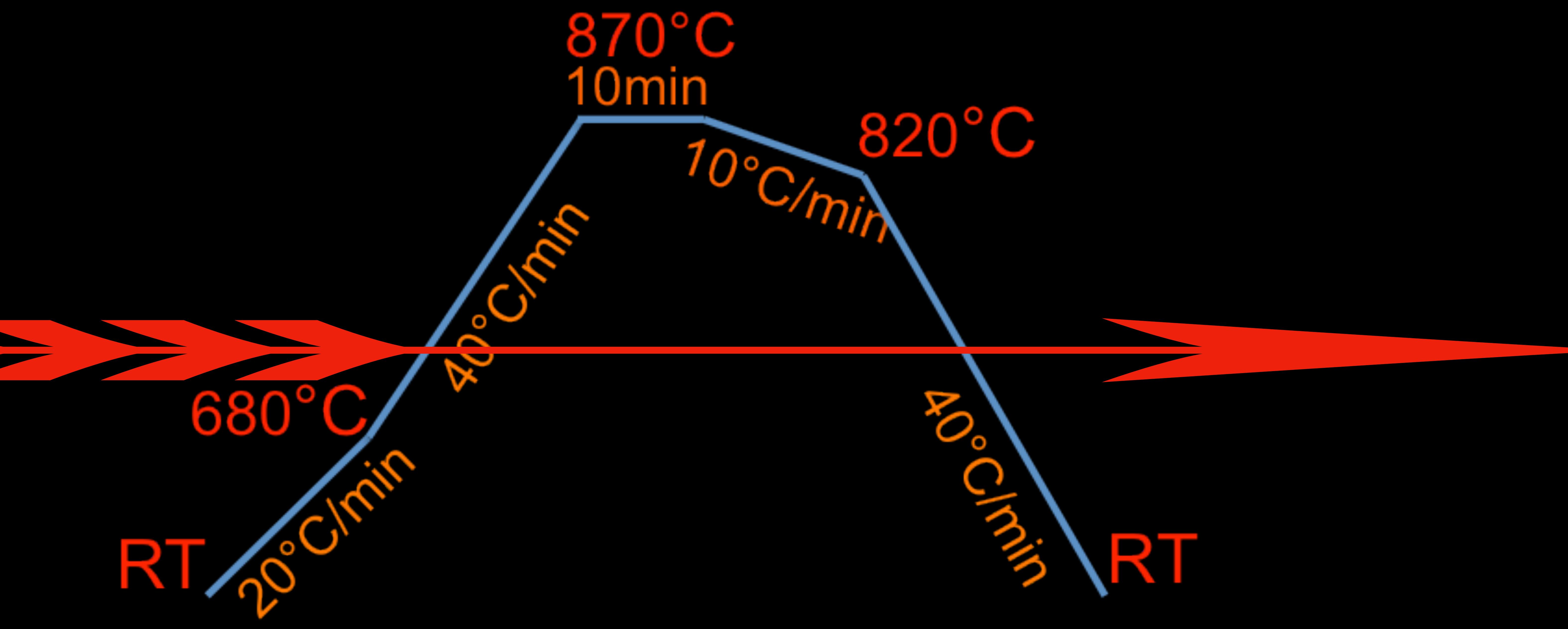
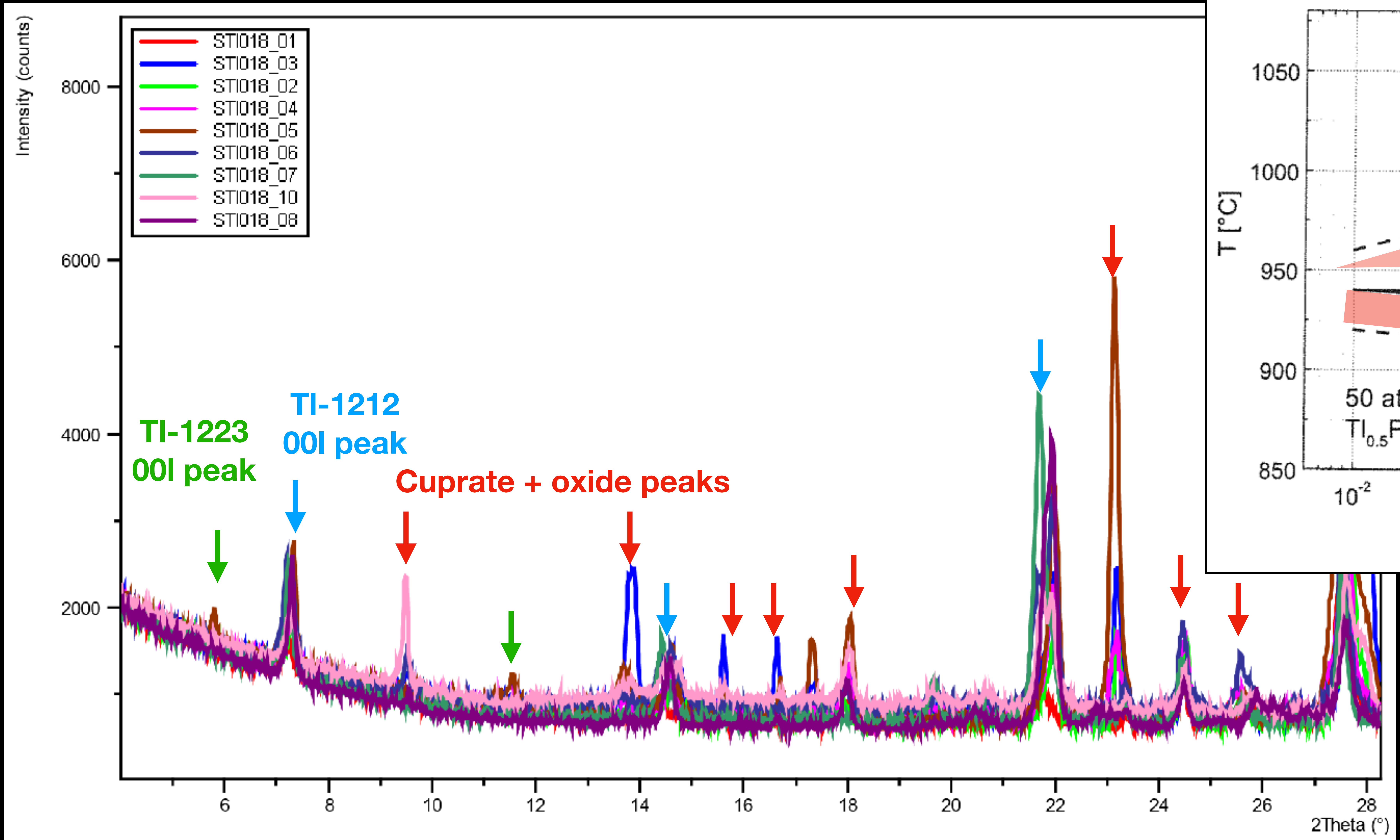
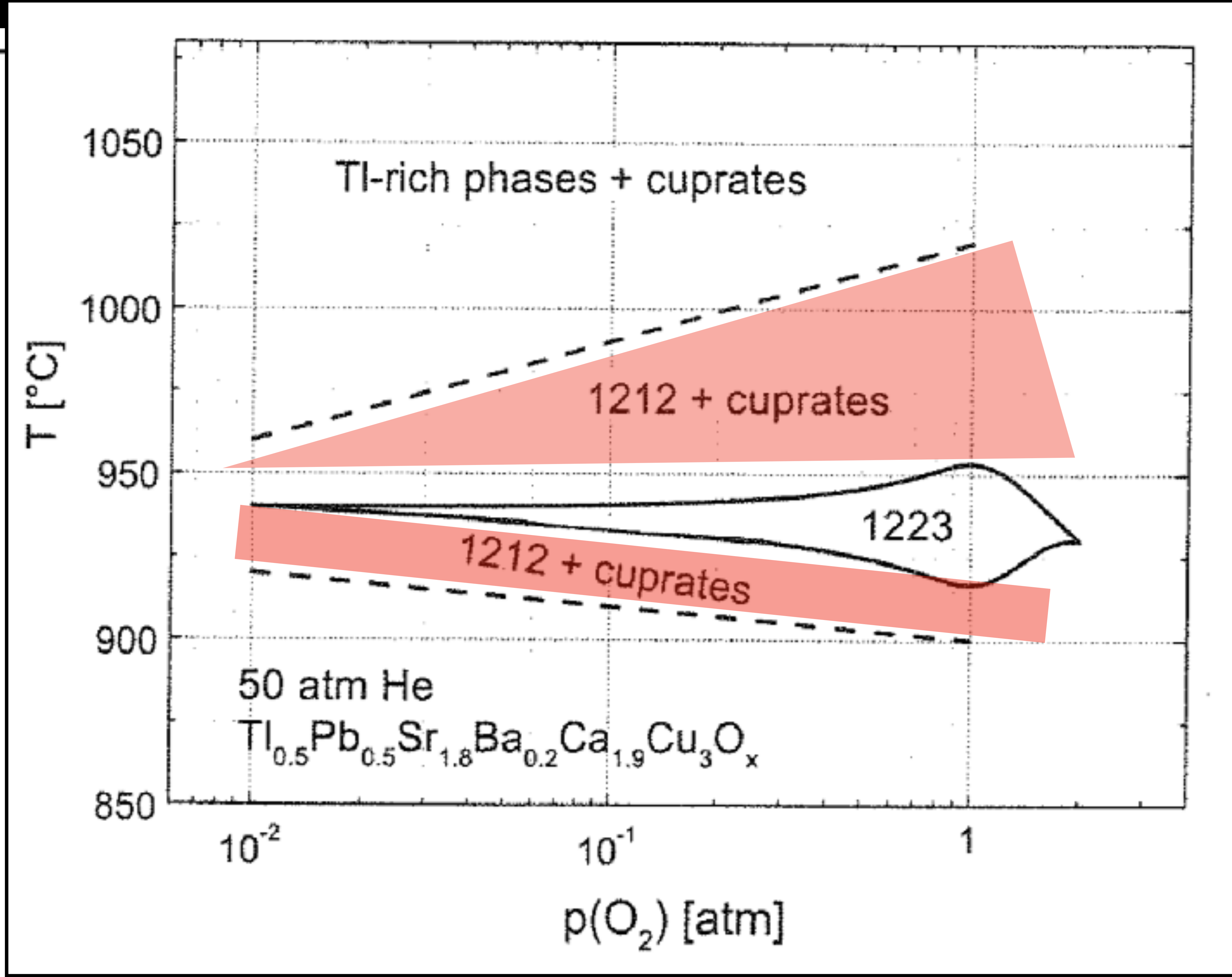


Thallium (oxide) is volatile above 700-715°C

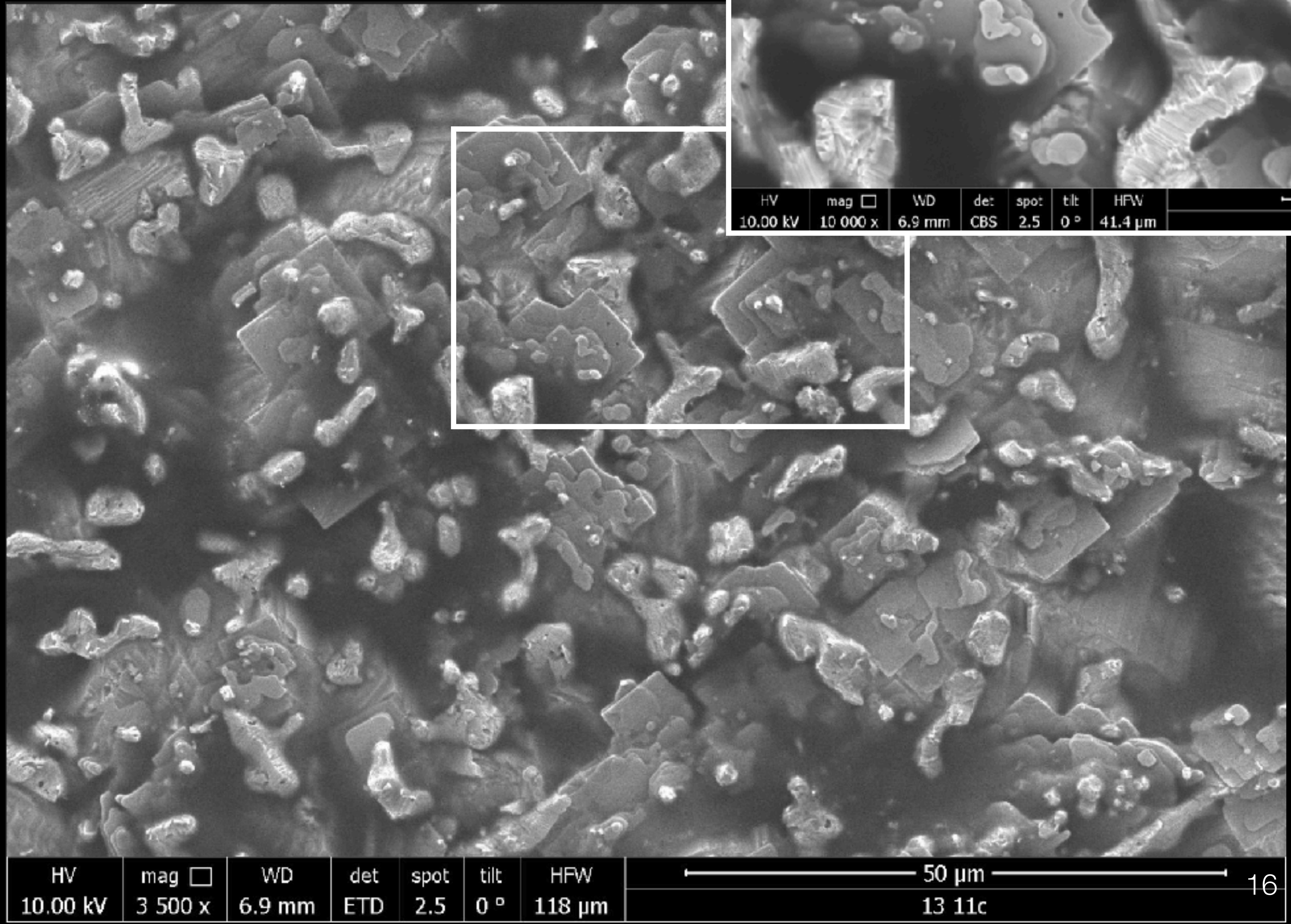
First Results

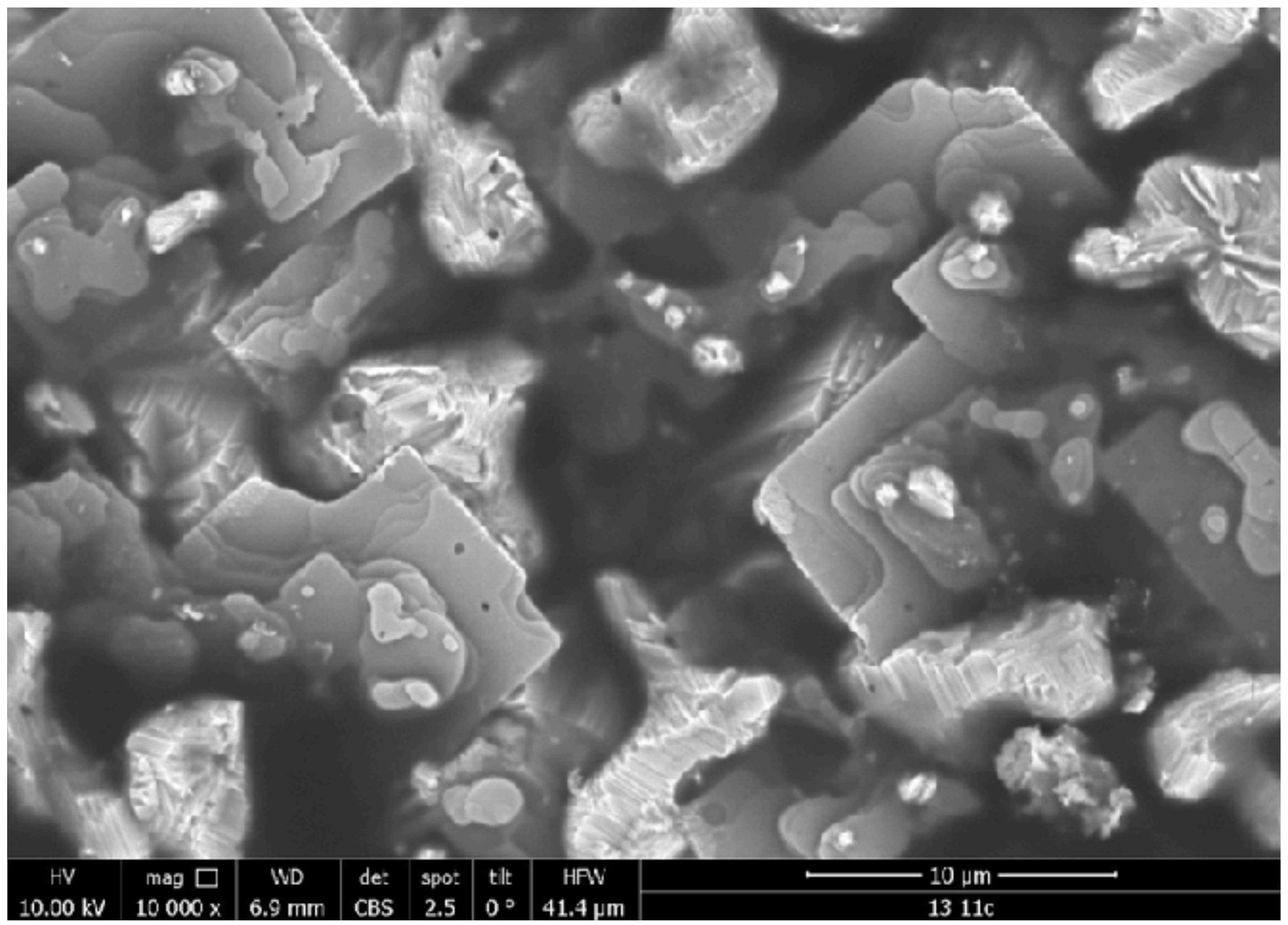




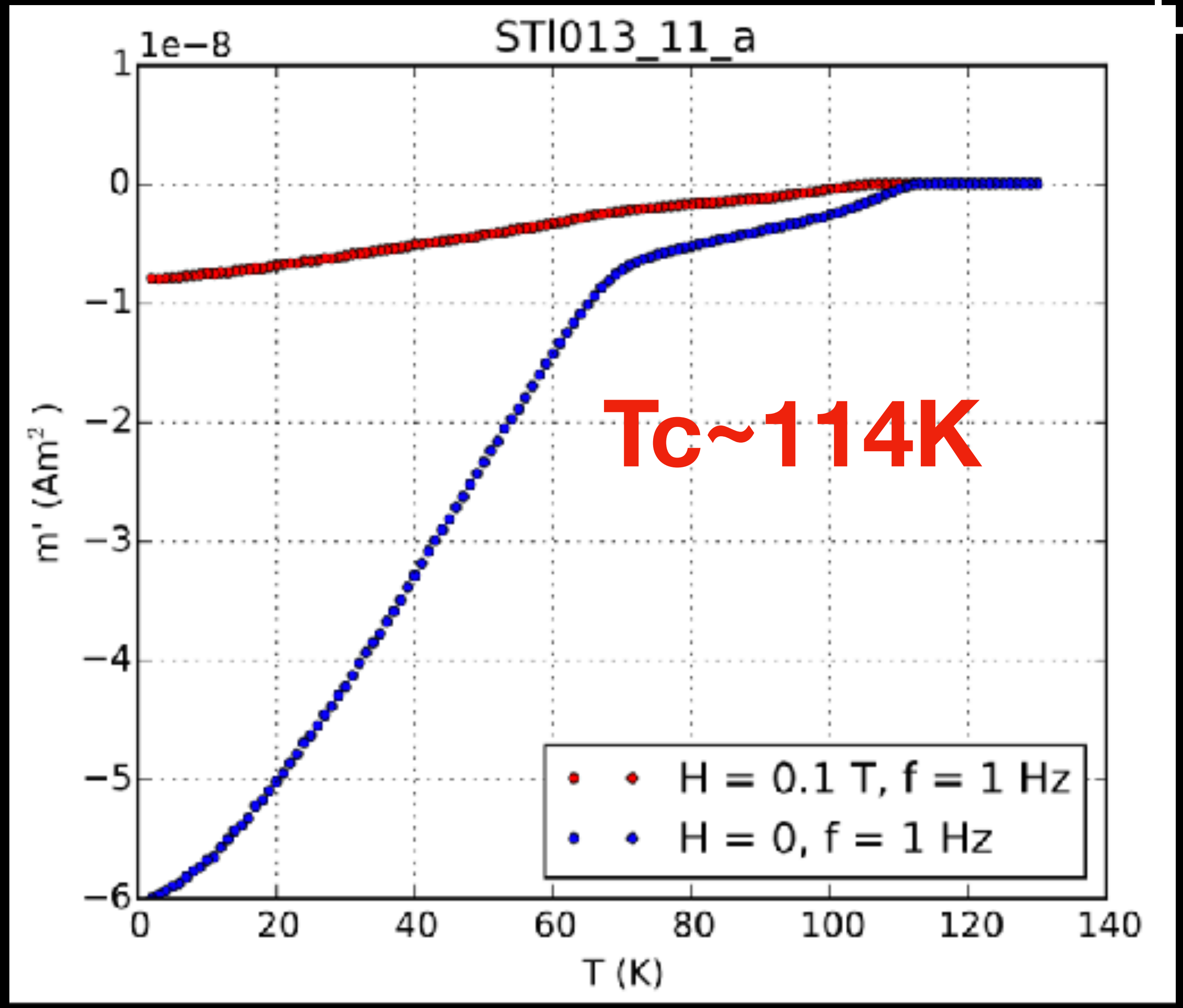
First Results

PLATE-LIKE GRAINS



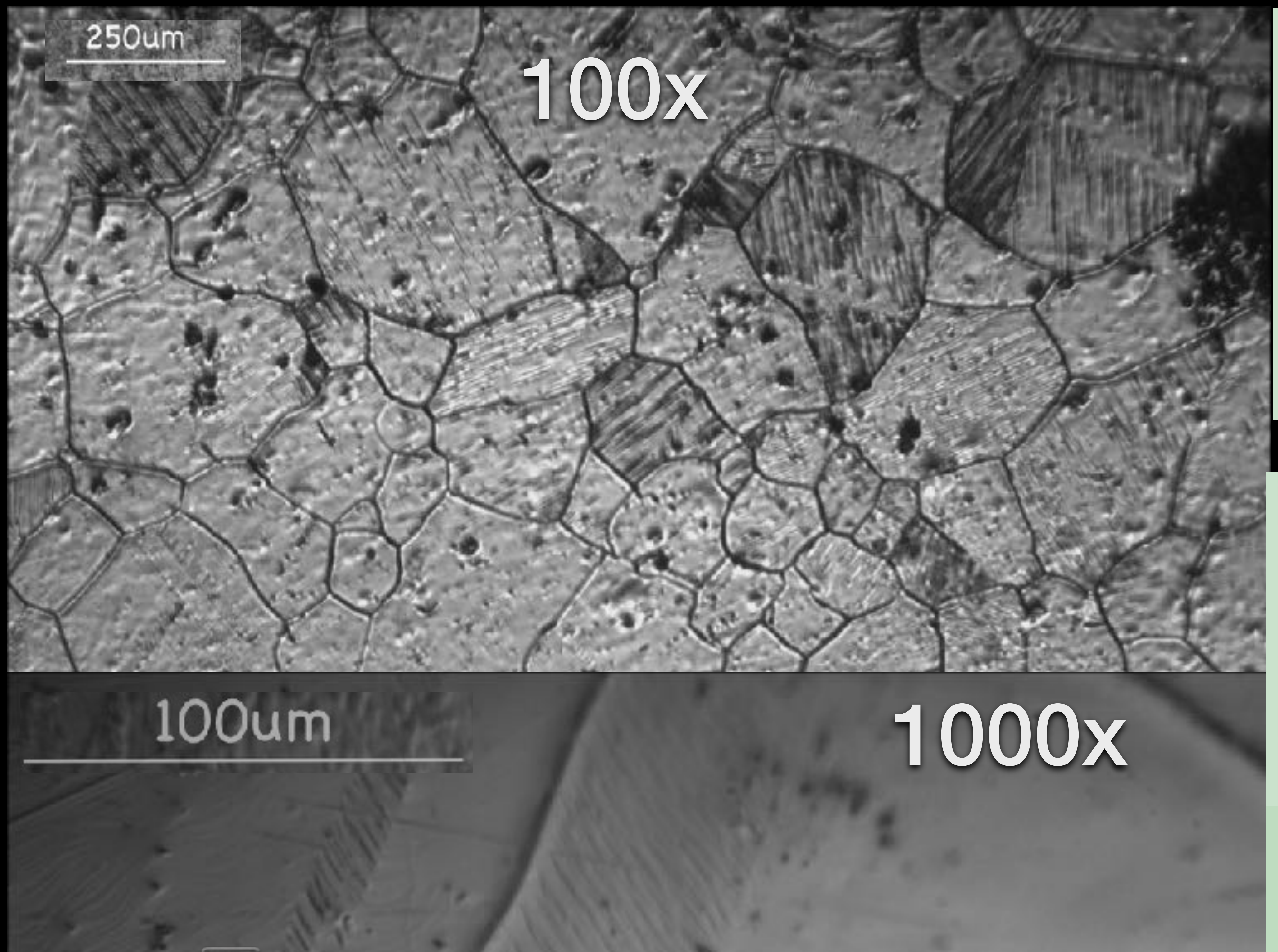


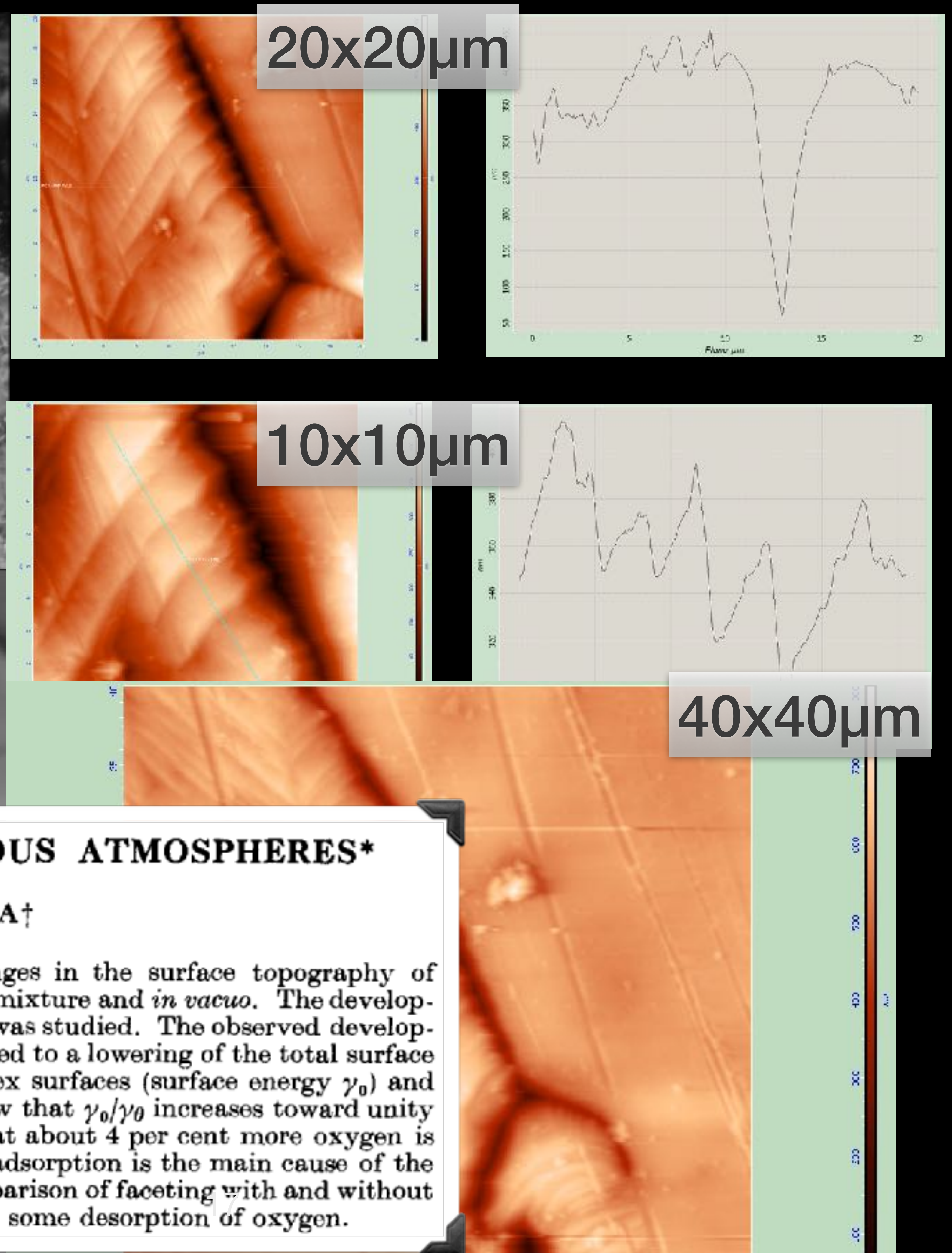
SEM/TEM analysis and PRELIMINARY TRANSPORT MEASUREMENTS

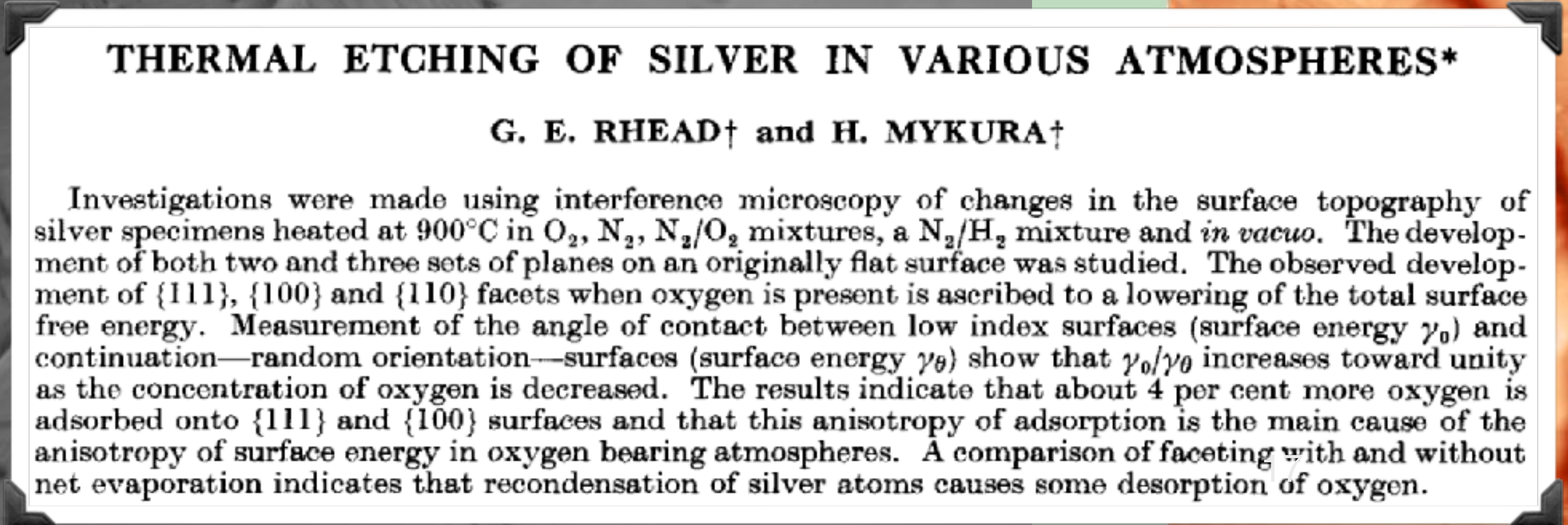


PLEASE SEE **S. HOLLEIS' POSTER** @17:00 on the **2AMSP08**

Substrate Issues





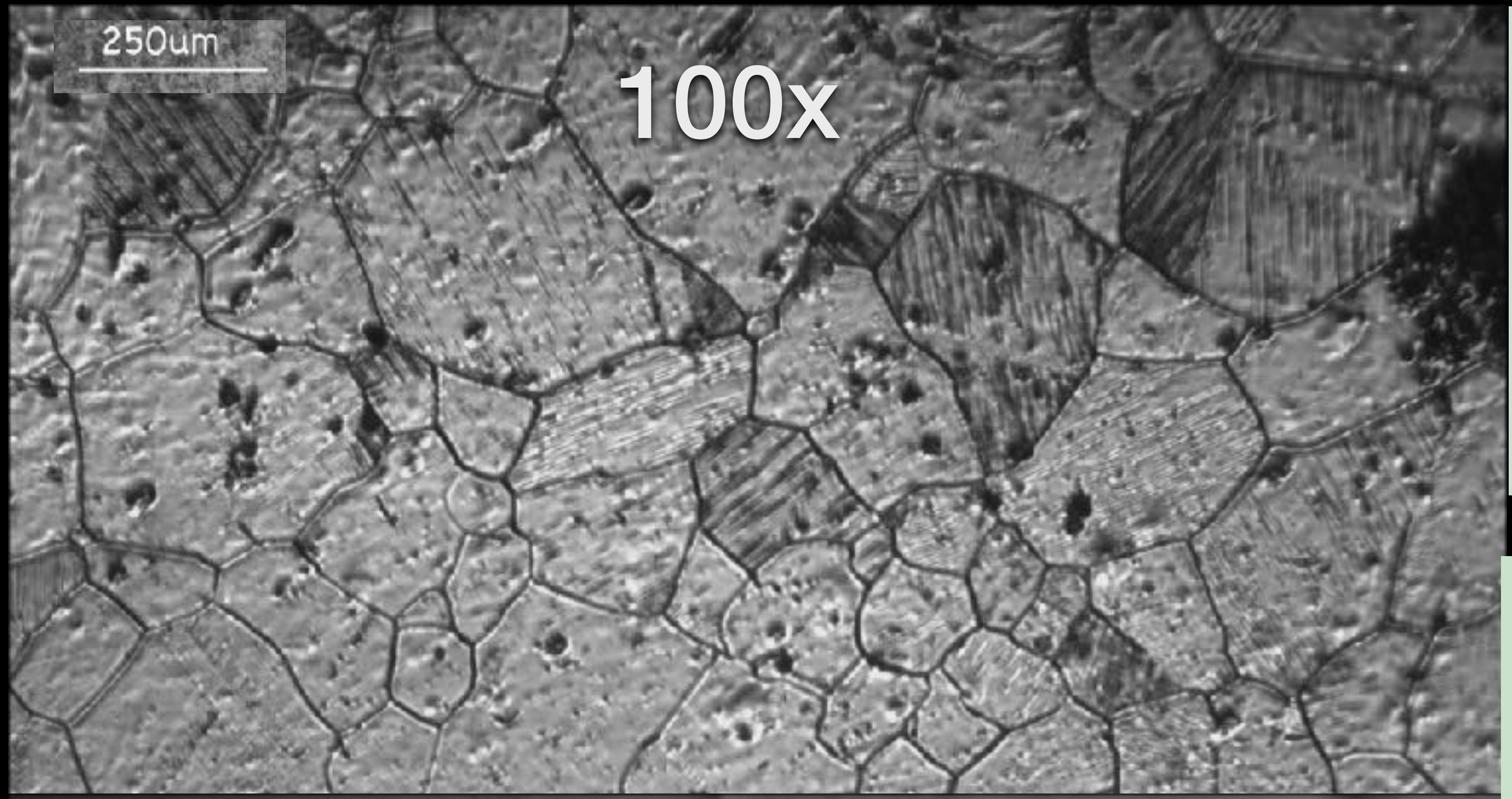


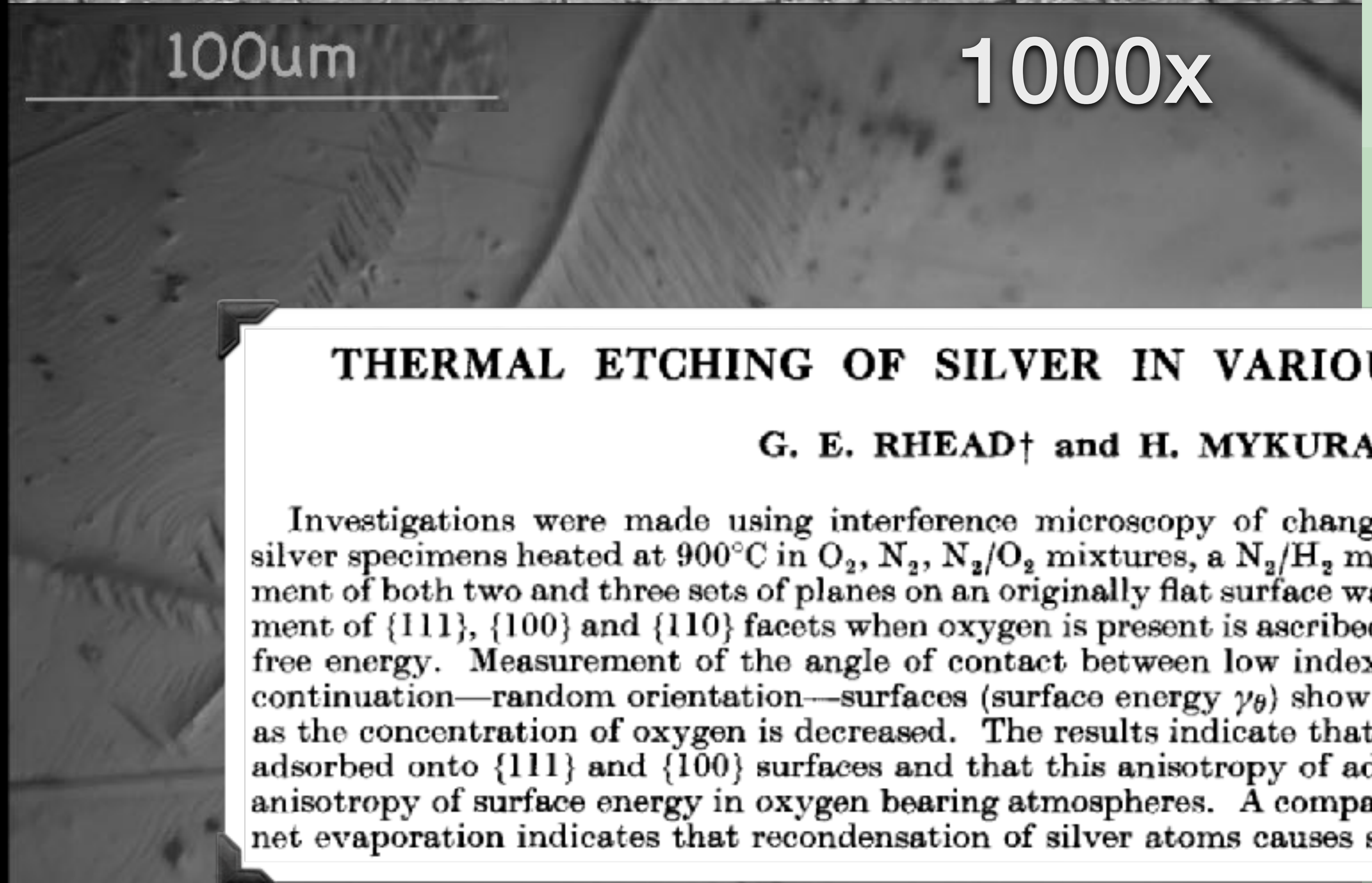
THERMAL ETCHING OF SILVER IN VARIOUS ATMOSPHERES*

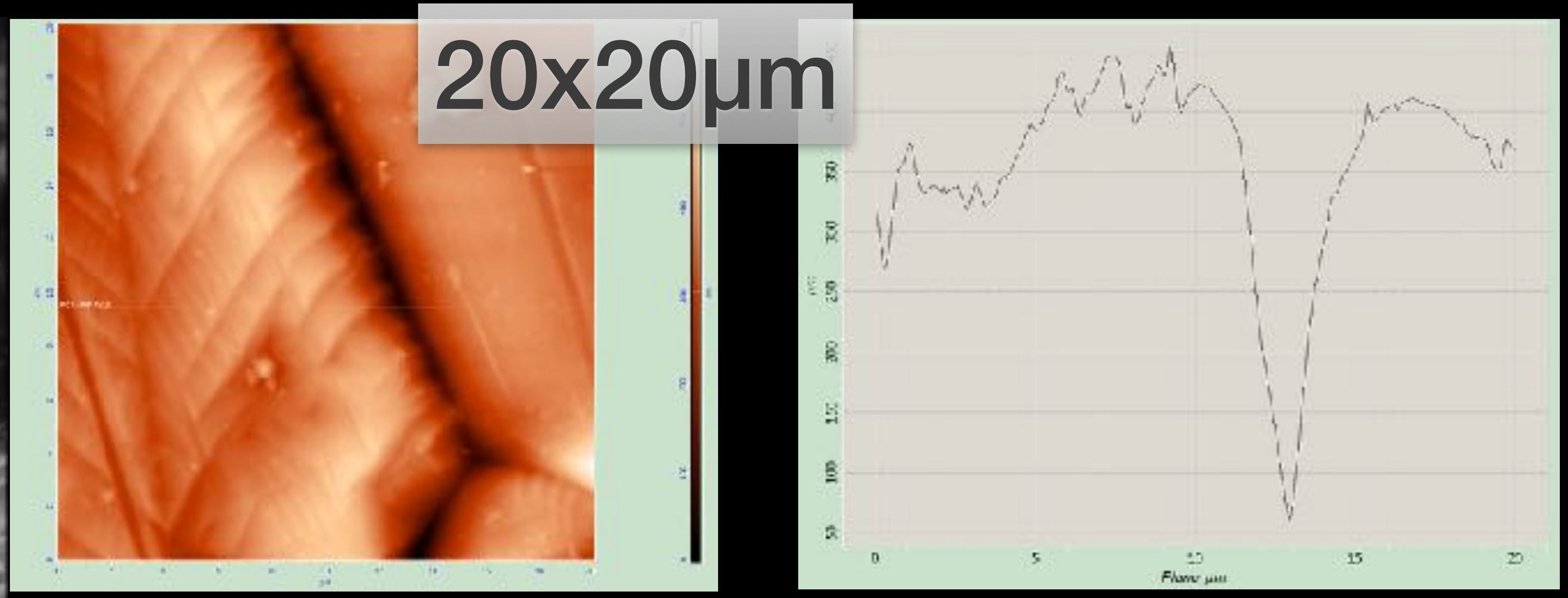
G. E. RHEAD† and H. MYKURA†

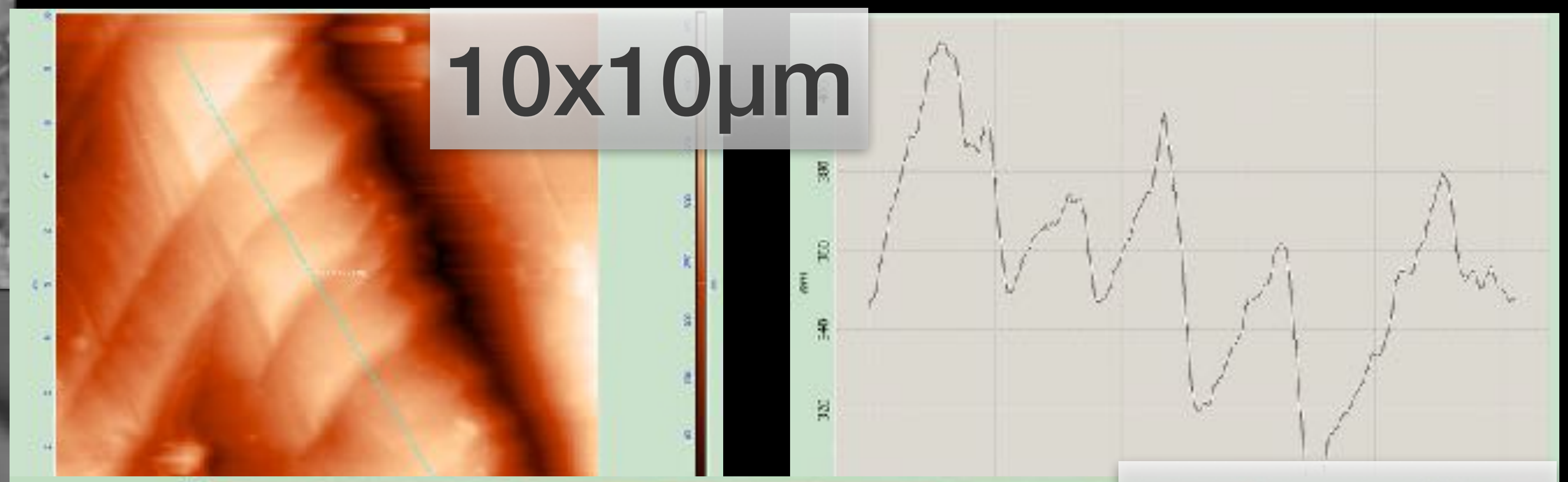
Investigations were made using interference microscopy of changes in the surface topography of silver specimens heated at 900°C in O_2, N_2, N_2/O_2 mixtures, a N_2/H_2 mixture and *in vacuo*. The development of both two and three sets of planes on an originally flat surface was studied. The observed development of {111}, {100} and {110} facets when oxygen is present is ascribed to a lowering of the total surface free energy. Measurement of the angle of contact between low index surfaces (surface energy γ_0) and continuation—random orientation—surfaces (surface energy γ_θ) show that γ_0/γ_θ increases toward unity as the concentration of oxygen is decreased. The results indicate that about 4 per cent more oxygen is adsorbed onto {111} and {100} surfaces and that this anisotropy of adsorption is the main cause of the anisotropy of surface energy in oxygen bearing atmospheres. A comparison of faceting with and without net evaporation indicates that recondensation of silver atoms causes some desorption of oxygen.

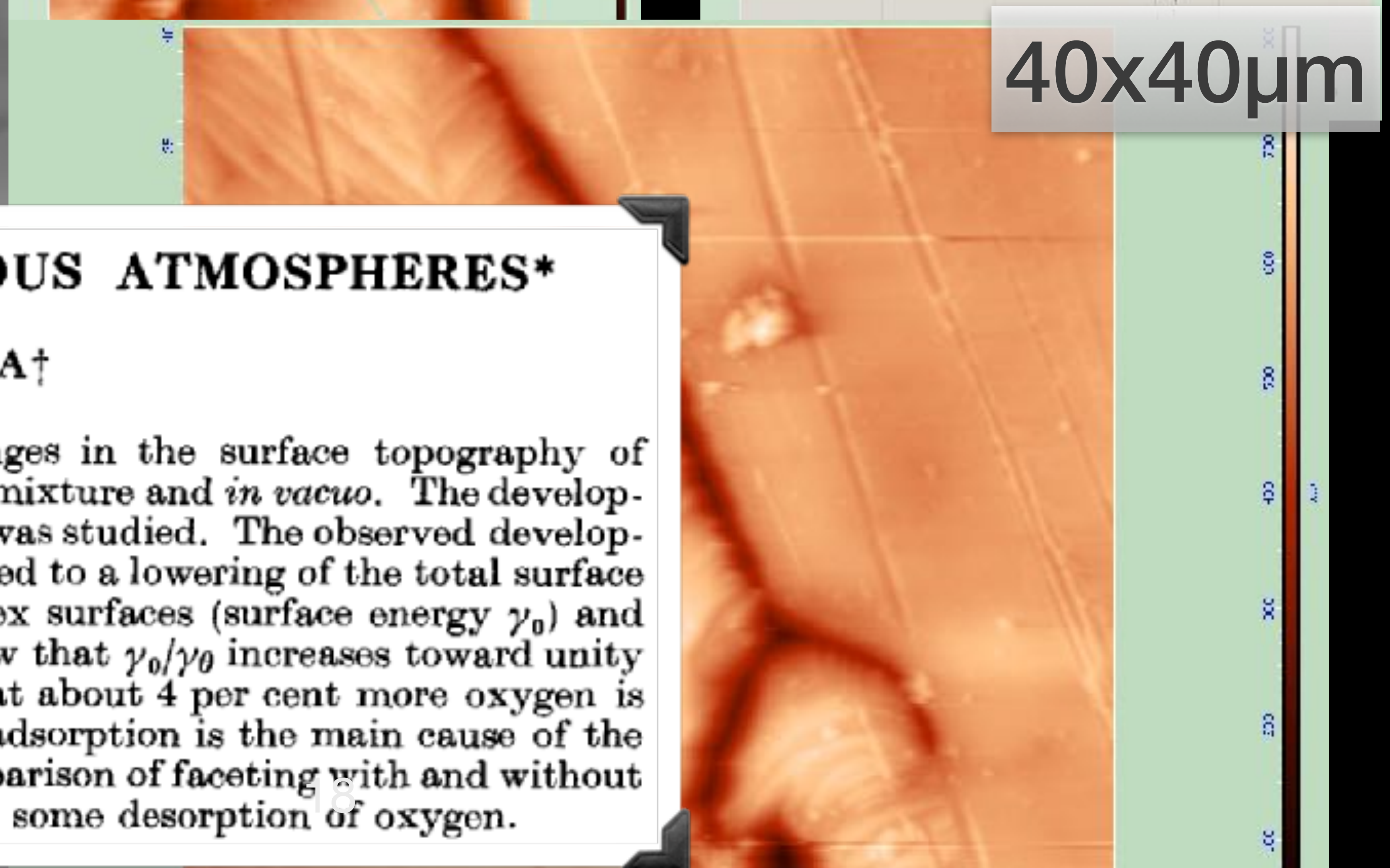
Substrate Issues











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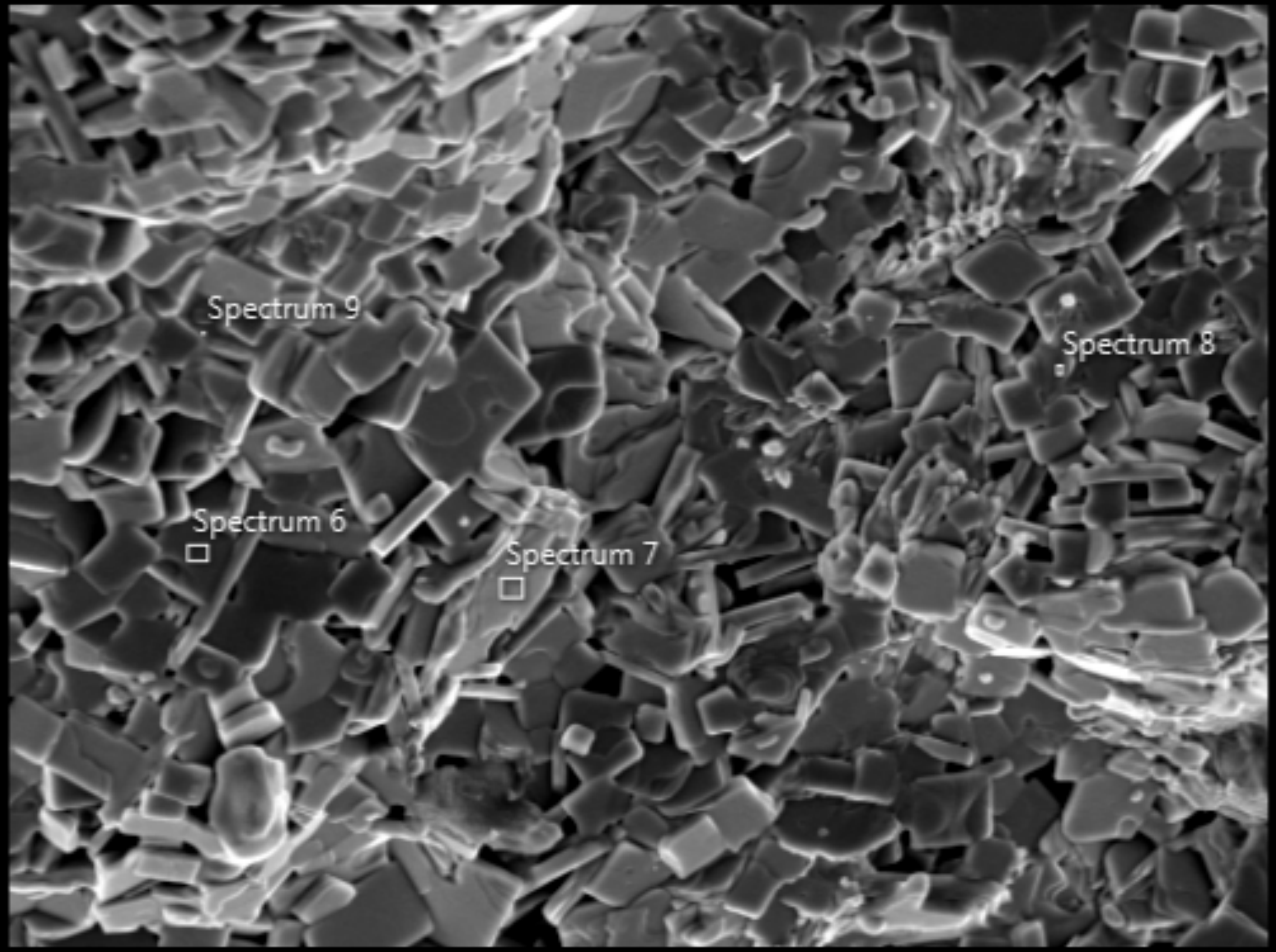
WHILE

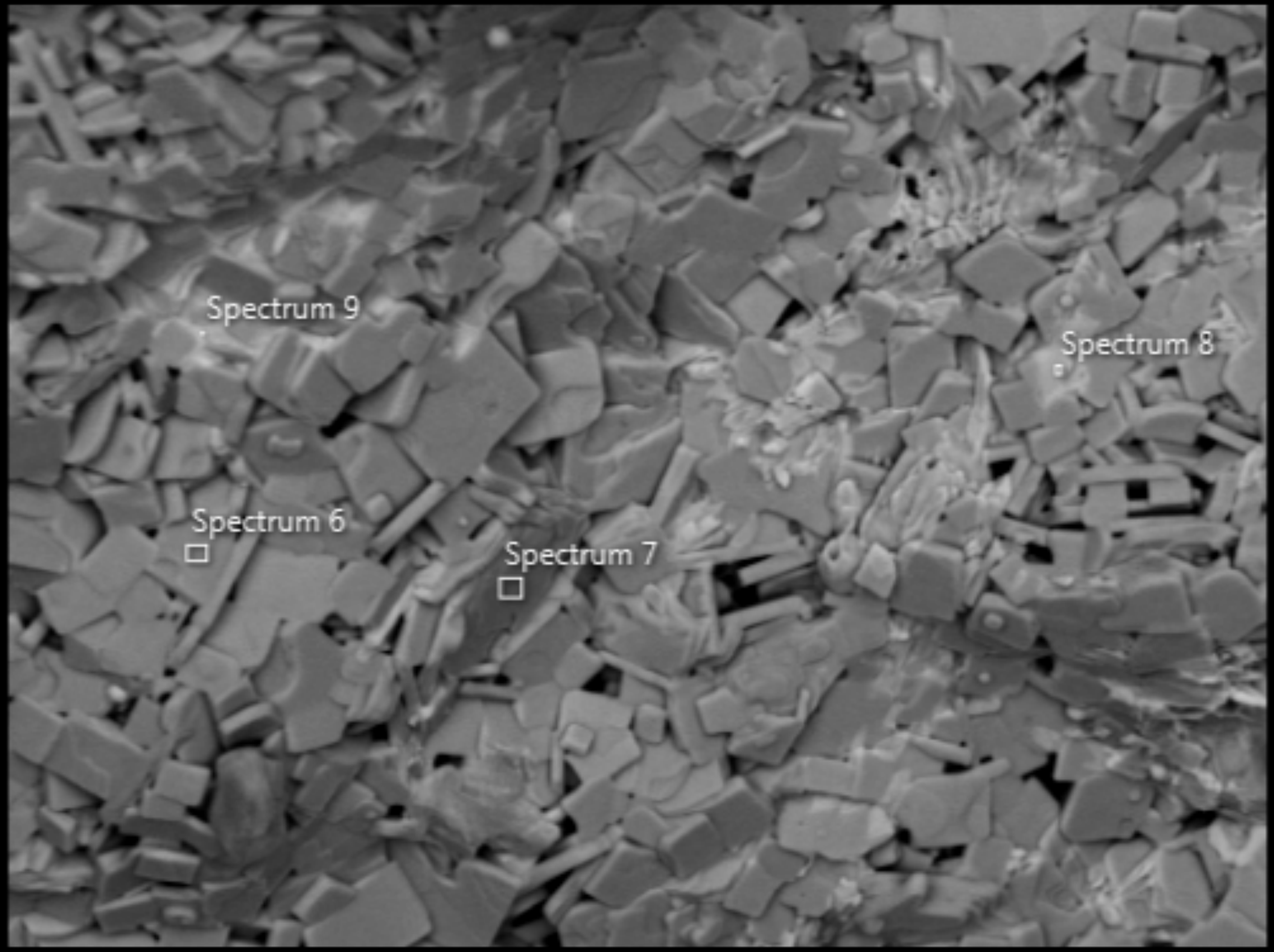
STARTING TO STUDY FLAT SUBSTRATES (Single Crystals > > glass > inconel...) WITH A SILVER COATING

For large scale production we should start thinking about a silver coating instead to a silver substrate

Alternative method for thallination

Breaking and tilting of the pellets





Preparation of Tl-1223 pellets

> > right Tl,Bi,Pb evaporation conditions

Quant Results View

Viewed Data: Multiple Spectra

Result Type: Atomic %

Spectrum Label	O	Ca	Cu	Sr	Ag	Ba	Tl	Pb	Bi
Spectrum 6	41.24	9.74	24.49	13.58		2.38	5.32	2.24	1.02
Spectrum 7	55.53	5.56	24.30	8.46		0.73	2.88	1.81	0.73
Spectrum 8	49.43	13.76	5.13	11.52	1.05	0.76	5.99	7.62	4.74
Spectrum 9	42.94	8.10	9.24	6.69		18.03	2.35	4.24	8.41

Mixture of Tl-1223 / Tl-1212

Conclusions & Perspectives

1. HTS are promising;
2. First superconducting samples has been produced;
3. Silver Substrate/coating studies;
4. New Thallination method

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