



## **Minutes of the 5<sup>th</sup> WP15 meeting held on 22<sup>nd</sup> May 2018 at RTU, Riga, Latvia**

### **WP15: Thin Film for Superconducting RF Cavities (SRF)**

**Present:** Oleg Malyshev (Chair), Reza Valizadeh (STFC)  
Claire Antoine (CEA),  
Cristian Pira (INFN),  
Eugen Seiler and Rastislav Ries (IEE),  
Oliver Kugeler (HZB),  
Artur Medvid, Aleksej Katašev, Pavel Onufrijev and Jevgenij Kaupuz (RTU),  
Michael Vogel (University Siegen)

**Apologies:** Mauro Taborelli, Giovanna Vandoni, Alban Sublet, Walter Venturini Delsolaro (CERN), Xin Jiang, Thorsten Staedler (University Siegen), Fedor Gömöry (IEE), Philippe Goudket (STFC), Graeme Burt (Lancaster Uni).

Meeting indico page is <https://indico.cern.ch/event/731011/> .

### **Minutes:**

#### **1. WP2.**

Cristian Pira (INFN) presented the status of WP2 at INFN on surface polishing with EP, SUBU, EP+SUBU and tumbling, optical inspection, characterisation for surface roughness and SEM.

*Status of work: completed*

#### **2. WP3.**

Cristian Pira (INFN) presented the status of WP3 at INFN.

5 samples polished with 4 different techniques at INFN and with SUBU at CERN were deposited with Nb film:

- L8 (tumbling), L16 (EP+SUBU) Initially planned
- L20 (SUBU LNL), L21 (EP) Spare samples at LNL
- C10 (SUBU CERN) Arrived from STFC on 19/04

After deposition the samples were characterised with optical inspection, characterisation for surface roughness, SEM (confirming that morphology of Cu surface is replicated by the Nb film), EDS (showing no visible contaminations in the film) and XRD.

Samples have been cut and sent to other partners.

*Status of work: completed*

Michael Vogel has reported a status of work in the University Siegen.

5 samples polished with 4 different techniques at INFN and with SUBU at CERN were deposited with Nb film. They were characterised with AFM (for surface morphology and roughness), SEM (surface and cross sectional investigation, the latter on one sample only) and EDS (for elemental analysis).

Samples have been cut and sent to other partners.

*Status of work: completed*

### ARIES sample cut and shipping

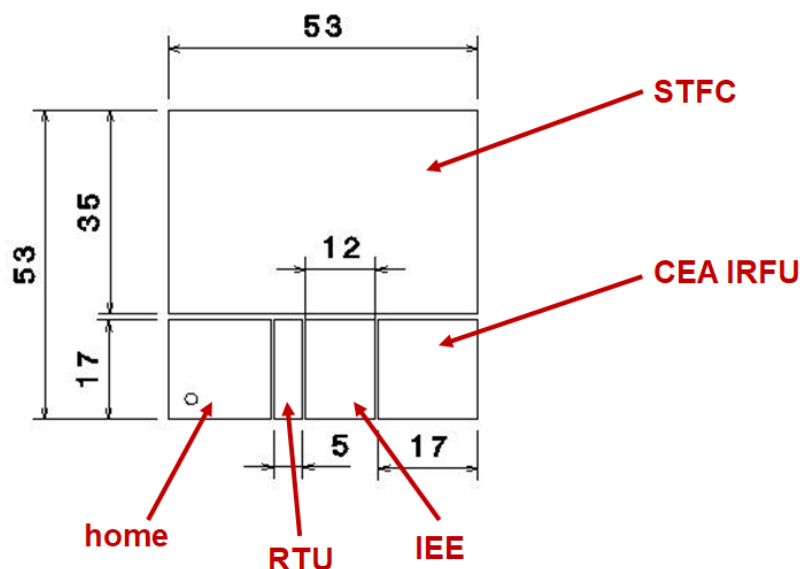


Figure 1. A layout of sample cut after 1<sup>st</sup> deposition and where each part should be shipped to.

Reza Valizadeh reported the WP3 progress at STFC:

Samples C7, L13, L18, L19 and L4 were coated with 3  $\mu\text{m}$  thick Nb films (TBC in future thin film characterisation). Samples are being cut and will be analysed with SEM (planar and X-section), XRD and EDS.

Samples will be cut and sent to other partners over next week.

*Status of work: almost completed*

*Action on Reza Valizadeh: to check and confirm the film thickness*

Artur Medvid (RTU) reported the WP3 progress at RTU.

### **Laser polishing of copper surface.**

Results on laser polishing. Initial results demonstrated that the deep scratched can be removed by laser polishing, but surface RA  $\approx$  200 nm, i.e. much higher than for other techniques. More work should be done.

### **Laser treatment of Nb film.**

The task is to improve the quality Nb film by laser irradiation

- (a) to improve a Nb thin film adhesion on Cu substrate,
- (b) to increase the Nb grain size and to anneal the defects.

The sample provides by Reza Valizadeh (Nr. 22/3/16) was irradiated with 4 different laser intensities: 140, 170, 253 and 320 MW/cm<sup>2</sup>. Afterwards they were characterised with AFM for surface topography, with XRD to determine the grain size and with scratch test for adhesion.

The critical delamination force for irradiated sample has increased with the laser dose by maximally 36%. The results can be explained by inter-diffusion of Cu and Nb during the laser treatment. Laser radiation leads to decrease of Nb surface roughness (RMS) from 8 to 1 nm. The size of Nb crystals can be increased and defects between grains (pinholes) can be eliminated by laser radiation.

*Status of work: ongoing*

*Action on Reza Valizadeh: to provide full sample history to Artur.*

Artur reminded that he is waiting for 53 x 53 mm<sup>2</sup> samples with 20-nm thick Nb film as planned for 1<sup>st</sup> year. After the laser treatment these samples will be returned to University Siegen and STFC for depositing 3 μm Nb film.

*Status awaiting the samples from partners*

*Action on Reza and Michel to deposit and send to Artur 1 or 2 samples cleaned in 1<sup>st</sup> year (53 x 53 mm<sup>2</sup>) with 20 nm thick Nb film (as agreed in 1<sup>st</sup> year programme).*

We also agreed on sending the 17 x 17 mm<sup>2</sup> (CEA IRFU) samples to Artur. Claire will receive the 53 x 35 mm<sup>2</sup> (STFC) samples.

*Action on Claire: forward the 17 x 17 mm<sup>2</sup> samples received by USiegen to Artur.*

*Action on Reza and Cristian: send 17 x 17 mm<sup>2</sup> (CEA IRFU) samples to Artur.*

*Action on Oleg: send 53 x 35 mm<sup>2</sup> (STFC) samples to Claire as soon as Claire's system is ready.*

Alexej Katashev (RTU) reported on first results on the Exoelectron emission from two samples provided earlier by Reza.

10 samples have been received from INFN and Siegen for analysis. 4 samples has been measured, others should be completed soon. More results are needed for any conclusions.

*Status of work: ongoing*

*Action on Reza Valizadeh: to provide full sample history to Alexej.*

*Action on Alexej Katashev: to complete sample analysis.*

### **3. WP4.**

Eugen Seiler (IEE) reported a status of AC/DC superconductivity characterisation facilities.

10 samples have been received:

- C10, L8, L16, L20, L21 –from INFN/LNL
- C1, L1, L10, L9, L23 – from Uni Siegen
  
- Samples for measurements (in PPMS) cut with “Diamond” saw, After cutting a line whole area was flushed with Ethanol, dried. Produced samples ~ 2 mm x 2 mm.
- DC magnetization of 4 samples were measured with PPMS (Physical Property Measurement System) with VSM
  - in perpendicular field
  - at T = 4.22, 5, 6, 7 and 8 K.
  - virgin mag. curve: B<sub>en</sub> (~B<sub>c1</sub> perp.), [ B<sub>p</sub>, B<sub>c2</sub>]

*Status of work: ongoing*

- A new set-up for 3<sup>rd</sup> harmonic voltage measurement is still in preparation.

*Status of work: ongoing*

Claire Antoine (CEA) reported a status of AC superconductivity characterisation facility upgrade.

- A new system is overcoming field measurement limit and tested up to  $B = 220$  mT (before it was limited to  $\sim 90$  mT).
- Issue : need for larger samples or concentrate the field with ferrite

*Status of work: ready for samples, but no samples will be measured in the following two months*

Oleg Malyshev (STFC) has reported on Superconducting properties evaluation at STFC.

- A facility development for superconducting sample evaluation consist of two vacuum tubular inserts (VTI) and 5 experiments:
  - VTI-A with RRR, RRR in magnetic field (operational) and Magnetic field penetration measurements on tubes (under final wiring)
  - VTI-B with Tubular resonator (operational) and Magnetic field penetration measurements on tubes (under final wiring)
  - Cryostat is operational,  $T \sim 3.5$  K reached at stage 2, but only  $T \sim 7.5$  K at the sample, problem is under investigation.
- Superconducting thin film test with a pill-box cavity in a dry cryostat
  - Cryogenic, vacuum and mechanical hardware is fully assembled
  - Wiring for heaters & thermometers started
  - Stainless RF cable being re-terminated and 2 flexible connectors and a feedthrough being manufactured

*Status of work: ongoing*

Oliver Kugeler (HZB) has reported on QPR development:

- An emphasis on limits in measurements,
  - Very high surface resistance at 1282 MHz in pulsed regime due to RF losses at the nc bottom flange.
  - Pick-up antenna development, reduced size of coupling loop.
- Sample procurement
  - Position 1: Nb high RRR sample
  - Position 2: Nb/Cu sample
  - delivery by September 2018.

*Status of work: ongoing*

#### **4. Discussion on Milestone Report MS50**

Cristian Pira (INFN) presented the status of Milestone Report MS50. The report have to be completed by 30<sup>th</sup> May 2018.

The present WP participants went through the report, putting in suggestions, corrections, putting a few actions on providing missing information.

*Action on Cristian Pira: to coordinate all necessary input and send the final report to Oleg by 31<sup>st</sup> May 2018. Revise the report after feedback from the Steering Committee within a week.*

*Action on all other participants: to provide the necessary input to Cristian before 30<sup>th</sup> May 2018.*

## **5. Planning for the 2<sup>nd</sup> year**

### **Task 15.2.**

- Base on the results of 1<sup>st</sup> year it was agreed that the future samples for deposition at Siegen University and STFC will be treated with two techniques only: EP and EP+SUBU5.
- INFN will continue exploring other surface treatments: SUBU5, Tumbling, Tumbling+SUBU5, etc., for depositing at INFN

### **Task 15.3.**

Oleg highlighted that a milestone report MS51 and a delivery report D15.2 should be sent to Steering Committee within 2<sup>nd</sup> year.

MS51: First samples exchanged (system 1 and 2, e.g. NbN and Nb<sub>3</sub>Sn) and deposited at partners (Task 15.3, 15.4) in month 14, i.e. mid-June 2018.

MS51 deadline is quite challenging due to delays within 1<sup>st</sup> year. Reza Valizadeh has already deposited his first Nb<sub>3</sub>Sn sample which was tested for RRR, however, no SC transition for temperatures down to 9 K was detected. No more samples can be produced at STFC before September 2018.

Artur suggested to send this Nb<sub>3</sub>Sn sample to him to try modifying the film phase with a laser irradiation to make it superconducting.

*Action on Reza Valizadeh: to send Nb<sub>3</sub>Sn sample to Artur.*

Michel Vogel could deposit a NbN sample. He need to check what a realistic date for the deposition is.

*Action on Michel Vogel: to deposit first NbN sample before 20<sup>th</sup> June 2018, if possible, or provide the realistic date for the deposition.*

*Action on Oleg: to send the report to Steering Committee.*

D15.2: Evaluation of systems 1 and 2 [month 24, i.e. to be ready by 30<sup>th</sup> March 2019]. Report on deposition, surface and structural analysis, DC and RF superconductivity evaluation of systems 1 and 2 (e.g. NbN and Nb<sub>3</sub>Sn) (Task 15.3 – Reza Valizadeh).

It was agreed that initially STFC will focus on Nb<sub>3</sub>Sn films and Siegen University on NbN films.

*Action on Reza Valizadeh: to agree the sample list with Michel Vogel, write sample flow through all partners and report a detailed work plan for the 2<sup>nd</sup> year at the next WP15 meeting.*

*Action on Reza Valizadeh: to coordinate all necessary input and send the final report to Oleg by 30<sup>th</sup> March 2019.*

#### **Task 15.4.**

As soon as copper sample substrates are delivered to HZB, three samples will be sent to INFN (*Action on Oliver*).

*Action on Oliver: please provide detailed technical drawings (and STEP files) from the samples asap.*

Two samples will be treated with EP and one sample with EP+SUBU5.

One EP treated sample will be sent to Siegen University, another to STFC to be deposited with 3  $\mu\text{m}$  of Nb film. Then both will be sent back to HZB.

*Action on Cristian Pira: prepare the treatment facility to suit the samples.*

Based on results and discussion it will be decided where the EP+SUBU5 treated sample should be deposited.

*Action on Reza and Michael – sample deposition*

The best of three tested samples can then be sent to CERN for comparison of two testing facilities: at HZB and CERN.

*Action on Oliver – sample testing and overall coordination.*

## **6. Next meeting**

Many WP15 members are going to attend the 8<sup>th</sup> International Workshop on Thin Films and New Ideas for Pushing the Limits of RF Superconductivity on 8-10 Oct. 2018 in LNL/INFN (Italy). <https://agenda.infn.it/confUser.py?confId=15746>

Therefore, the next WP15 meeting will be held at the same location of LNL/INFN immediately after the workshop. Preliminary, the WP15 will start after lunch on 10<sup>th</sup> Oct. and finish before lunch on the 11<sup>th</sup>.

*Action on Cristian Pira: to host the WP15 meeting and ensure VidyO conferencing for remote connection.*