Minutes of the 8th WP15 meeting held on 31st Jan. 2019 by Vidyo

WP15: Thin Film for Superconducting RF Cavities (SRF)

Present: Oleg Malyshev (Chair), Reza Valizadeh, Sepideh Aliasghari (STFC), Alban Sublet, Walter Venturini Delsolaro (CERN), Eugen Seiler (IEE), Cristian Pira, Eduard Chyhyrynets (INFN), Oliver Kugeler, Dmitry Tikhonov (HZB), Artur Medvid, Pavel Onufrijev, Jevgenij Kaupuz, Aleksej Katashev (RTU), Michael Vogel, Stewart Leith (University Siegen)

Apologies: Claire Antoine (CEA), Giovanna Vandoni, Mauro Taborelli, (CERN), Xin Jiang, Thorsten Staedler (University Siegen), Fedor Gömöry (IEE), Philippe Goudket (STFC), Tobias Junginger, Graeme Burt (Lancaster Uni).

Meeting Indico page is https://indico.cern.ch/event/791729/ .

Minutes:

1. Introduction

Oleg opened the meeting. He mentioned that the main emphasis of this meeting will be on Delivery report D15.2 and QPR sample preparation and experiment. Other contributions will be discussed at the end of the meeting.

D15.2: Evaluation of systems 1 and 2.

- Report on deposition, surface and structural analysis, DC and RF superconductivity evaluation of systems 1 (Nb_3Sn) and 2 (NbN) and Superconductor-Insulator-Superconductor (SIS) multilayer coating.
- Lead Author: Reza Valizadeh
- Main contributions from:
  - Reza Valizadeh (STFC): Nb_3Sn deposition and material characterisation;
  - Michael Vogel, Stewart Leith (University Siegen): NbN synthesis and material characterisation (topography, crystallinity, chemistry)
  - Eugen Seiler (IEE), O. Malyshev (STFC): SC properties
  - Cristian Pira (INFN), A. Sublet (CERN): substrate preparation.
- Any level of contribution is welcome from other partners.
- Report D15.2 deadlines:

- It should be submitted to H2020 by month 24 (30th April 2019), this is a date when ARIES leaders file final document after review and revision.
- This requires that WP15 should submit the report to ARIES leaders 1.5 month before, i.e. **on 15th March**
- We will receive it back with comments by 31st March, and we should incorporate them in the report before 15th April.

It was agreed on using a collaborative document (e.g. GoogleDocs) to collect input from everyone. Reza is happy to use it if somebody helps to set it up.

2. Delivery report D15.2

Reza Valizadeh reported on deposition of Nb_3Sn at STFC

- In total four samples have been deposited during the last month.
  - Nb/AlN/Nb_3Sn on copper
  - Nb_3Sn on LNL EP copper
  - Nb_3SN on DL EP copper
  - Nb/Nb_3Sn on copper
  - Nb/AlN/Nb_3Sn on sapphire
- In all cases the deposition temperature was kept at 650 °C and the substrate was heated 18 hours prior to deposition.
- Samples will be characterised with surface science instruments within 2 weeks
- Four samples 2 mm x 2 mm will be send to IEE within a week for SC evaluation.

Stewart Leith reported on sample preparation and deposition of NbN at University Siegen

- In-house surface treatments and its improvement by SUBU and EP (2 student works)
- 4-point-probe measurement device ready, from 300 to 77 K; 4.2 K (T_c, RRR) planned for the end of 2019
- NbN deposition on Cu and Si substrates as a function of Temperature, Bias Voltage, Pressure and N2%, Cathode power, Gas type (Ar/Kr).
- A first series of 8 samples (2^3 factorial study) has been finished, analysis by master student underway
- Another 5 samples for tests at IEE ready
- Film thickness varies due to N_2 variation
- New series of 36 samples (2^{6-1} partial factorial study) for optimisation of NbN currently underway, completion end of March
- Samples will be characterised concomitantly with surface science instruments
- Five samples 5 x 5 mm^2 will be send to IEE within a week for SC evaluation to understand the effects of N_2% on SC properties

Reza advised to study the film stoichiometry, preferably with RBS, many facilities are available in Germany.

3. QPR

Dmitry Tichonov reported on QPR mechanical polishing at HZB

- After machining the copper samples have a visible trace of machining, so they were mechanically polished with grinding paper.
- Deep traces of machining are no longer visible but surface is not shiny anymore.
- R_a and R_z were not measured after mechanical polishing.

Cristian Pira reported Status of QPR polishing

- Samples arrived to LNL/INFN on Tuesday 29/01
- Next week tests on spare sample
- Meeting to discuss the test
- Samples will be ready in 3 weeks
  - Time between polishing and deposition should be as short as possible, so Cristian need to know the date of readiness from both STFC and Siegen
- To decide: how many samples with SUBU and how many with EP?
  - It has been decided to make first three sample with SUBU and deposit with Nb at three facilities: Siegen, STFC and INFN
- To decide: how to ship the samples and what or if any cleaning required?
  - After polishing
  - After deposition

➢ HZB has a design for polymeric 3D printed case. More cases can be ordered.

Sepideh mentioned about possible chemical contamination of sample from the case.

Reza: Deposition lab prefer to apply no post-delivery treatments. He suggested to use either CF or ISO flanged case (a tube and two blank flanges) that can be pumped and filled back with N_2.

➢ HZB will re-design the case in stainless steel with ISO flanges.

It was concluded that experience on substrate and sample transport at INFN, HZB, CERN and JLab should be collated and employed.

Action on Cristian to draft the procedure on sample preparation after delivering to deposition labs.

QPR deposition

- Reza Valizadeh (STFC):
  - STFC will be ready provisionally in 4 – 6 weeks
  - A dummy Al sample has been machined and will be used for calibrating the deposition chamber and the deposition parameters.
  - System will be calibrated for both HiPIMS and DC mode deposition.
  - The QPR can be heated to 450 °C and can be continuously rotated while being deposited.
    - Two magnetron will be used for deposition to cover both the front face (Cu) and side (Nb)

- Deposition on the copper front face required one magnetron only and does not require rotation, thus it is much simpler.

It was discussed that Nb side coating is not required for Nb film, but this could be important with other films if samples studied at T > 9.5 K.

- Michael Vogel (Siegen):
  - QPR sample holder ready. Siegen will be ready after NbN optimisation is completed (in 2-3 months).

- Cristian Pira (INFN):
  - INFN will be ready in 2 months.

QPR measurements:

- Oliver: Facility at HZB is ready
- Walter: Facility at CERN is ready
  - Advance planning is necessary to adjust a schedule of measurements

Action on Reza and Michael:

- *let Cristian to know when you are ready for a sample to be deposited*
- *let Oliver and Walter to know when you are ready for a sample to be delivered to them*

Action on Oliver: to continue coordinating all activities related to QPR samples

4. **Task 15.2. (not covered above)**

Status of laser polishing - Artur Medvid

- Copper polishing of sample C18
  - Irradiated by nanosecond Nd:YAG laser radiation
  - Hardness of Cu has increased more than 3 times
  - Roughness of Cu has increased. It is difficult to determine the roughness by AFM because it is out of measurement range.
  - The main conclusion that different laser (CO_2 laser) should be used for copper polishing
- Treatment of Cu-Nb weld
  - Sample received from HZB was studied in how the Cu-Nb weld can be polished with a laser.
  - Some improvement of the surface roughness of the copper-niobium weld sample is observed after laser treatment
  - More powerful CO_2 laser required to explore this further
- A collaboration is in a process of setting up with another institute in Latvia to access other laser for these experiments.

5. **Task 15.3. (not covered above)**

Status of deposition facilities at STFC – *Reza Valizadeh*

- SUBU and EP polishing and surface characterisation work is ongoing at STFC
- Nb was deposited on Ta substrate. The interest was driven by the following: (a) The Ta lattice has a better match to Nb; (b) the Ta cavity could be produced with thinner walls than Cu and the Ta thermal conductivity will be sufficient.
- The main result is that film remain in Masson state at 4.2 K in a parallel magnetic field up to ~100 mT.

Status of laser annealing of Nb coated samples at RTU - *Artur Medvid*

- Sample Nr. 1/7/16 provide by Reza was irradiated by Nd:YAG laser (λ= 1.064 µm, τ =6 ns and intensity I=193.7 MW/cm2) in scanning mode with step 5µm in Ar atmosphere.
- The Nb surface roughness (RMS) of the non-irradiated has been reduced laser irradiation from 9.5 to 1.2 nm.
- SEM image show grain size increase and more polished surface. However, surface cracks appear on a surface with increasing laser intensity, in the same time, higher intensity results in disappearing pin holes as well. When intensity is too high, this results in appearing pin holes in Nb film caused by copper evaporation.
- Improvement in Ben measured by Eugen

Action on Artur: start writing a paper for SRF2019 on laser treatment of Nb film, coordinate an input from other participants.

Status of laser based film-substrate interface characterisation – *Aleksej Katasev*

- Vacuum in the measurement chamber has been kept at the level of 5×10^{-5} mbar. To estimate the effect of low vacuum on the phototermstimulated emission (PTSE) of the specimen, the specimen was annealed in such vacuum up to 500 ^{o}C, cooled down and annealed second time. At the second annealing, no PTSE signal was observed, that indicates that keeping in such vacuum does not affect surface features, responsible for PTSE. PTSE signal appears, if the specimen after annealing is removed from the chamber and immersed in oxidising media (distilled water), the intensity of PTSE increase with duration of oxidation.
- No other progress since last meeting to report.

Action on Aleksej: Previous results should be summarised in a report before next WP15 meeting.

6. **Task 15.4. (not covered above)**

Status of DC characterisation facilities at IEE: *Eugen Seiler*

- PPMS (Physical Property Measurement System)
  - Starting approx. in the week of 20th February
  - some interruptions foreseen due to maintenance
- 3rd harmonic voltage measurement
  - Defective transistor in linear amplifier identified
  - Acquiring a new amplifier

7. **Next meetings**

- 2nd ARIES Annual Meeting **8-12 April 2018 in Budapest (Hungary)**
  - 8th April (Monday): WP14 Additive Manufacturing Workshop
    - The idea is to bring together scientist and technologist from accelerator centres, aerospace and industry. One of the main topics is superconducting materials. Oleg was invited to give a talk, you all are very encouraged by WP14 coordinator to attend.
  - 9-11 April: plenary sessions.
    - All participants are expected to attend.
    - Oleg will give a talk as a WP15 coordinator.
    - The second 20' talk will be given by a Task 15.3 members (Reza to give a talk or to nominate a speaker) in a content of Delivery Report D15.2.
  - **12th April (Friday): the 9th WP15 meeting.**
    - we will start at 9:00 and should be able to finish the meeting at 16:00

- 19th International Conference on RF Superconductivity (SRF2019)
    - 15th February 2019 - Early abstract submission (to be considered as contributed orals) deadline
    - 1st April 2019 - Abstract submission deadline
  - Cristian Pira will present a talk on behalf of WP15: "Impact of the Cu substrate surface preparation on the morphological, superconductive and RF properties of the Nb superconductive coatings".
  - Other talks are welcome, please let me know if you are going to present WP15 work and please don't forget to acknowledge ARIES.
  - **The 10th WP15 meeting will be organise as a satellite event to the SRF2019**