



# Alternative surface processing pathway to the future of large scale SRF facilities

<u>Oleksandr Hryhorenko<sup>1</sup></u>, Claire Antoine<sup>2</sup>, Takeshi Dohmae<sup>3</sup>, William Magnin<sup>4</sup>, David Longuevergne<sup>1</sup>

- <sup>1</sup> IJCLAB, Laboratoire de Physique des 2 Infinis Irène Joliot Curie, 15 Rue Georges Clemenceau, 91400 Orsay, France
- <sup>2</sup> Département des Accélérateurs, de Cryogénie et de Magnétisme, CEA/DRF/IRFU, 91191 Gif-sur-Yvette, France
- <sup>3</sup> KEK, 1-1 Oho, Tsukuba, Ibaraki 305-0801, Japan
- <sup>4</sup> LAM PLAN, 7 Rue des Jardins, 74240 Gaillard, France





- Motivation for SRF applications (Why polish? Why alternative?)
- Alternative path for SRF cavity fabrication and surface processing
  - Requirements for Niobium
  - Requirements for industrialization

OUTLINE

- Metallographic polishing as an alternative technique
  - Polishing protocol
  - Progress in project
  - How long to polish?
- Conclusion and perspective

FACULTÉ DES SCIENCES

Université





- Alternative path for SRF cavity fabrication and surface processing
  - Requirements for Niobium
  - Requirements for industrialization

OUTLINE

- Metallographic polishing as an alternative technique
  - Polishing protocol
  - Progress in project
  - How long to polish?
- Conclusion and perspective

FACULTÉ DES SCIENCES

universite









27/10/2021



27/10/2021

Joint French-Ukrainian Workshop - Oleksandr Hryhorenko - 2021



# Why alternative polishing?



W Université de Paris DES SCIENCES

FACULTÉ

D'ORSAY

Possible reduction of the cost of cavity

surface processing (replace chemistry).





# Why alternative polishing?



Possible reduction of the cost of cavity surface processing (replace chemistry).



Achieve low surface roughness to improve the performance (removal of all type of defects, substrate preparation for thin film deposition) => possible reduction of the cost of accelerator manipulation CBP FΡ FΡ

Thesis Hryhorenko Constructed ilC Under construction  $10^{4}$ 16 000 Projects cavities Number of SRF cavities Total number  $10^{3}$ FCC XFEL CESC Project X CEBAF ~ 800 cavities EURISOI  $10^{2}$ MYPPH FLASH Existing SI Past SRF TRISTAN Courtesy of Cooper  $10^{1}$ IFMIF-EVEDA SuperKEKB BERL in PRO MESA PERLE Nb<sub>3</sub> Sn Nb  $10^{0}$ ELETTRA TLS A0 Photoinjector Future SRF 1970 198019902000 20102020 2030 2040 2050Years

FACULTE

D'ORSAY

universite

DES SCIENCES

CNIS

W



# Why alternative polishing?



Possible reduction of the cost of cavity surface processing (replace chemistry).



Achieve low surface roughness to improve the performance (removal of all type of defects, substrate preparation for thin film deposition) => possible reduction of the cost of accelerator manipulation EP (CBP + EP)

Courtesy of Cooper





Improve environmental footprint and worker safety (remove or at least reduce the amount of used acids)

FACULTE

OPSAN

DES SCIENCES







OUTLINE

- Motivation for SRF applications (Why polish? Why alternative?)
- Alternative path for SRF cavity fabrication and surface processing
  - Requirements for Niobium
  - Requirements for industrialization
- Metallographic polishing as an alternative technique
  - Polishing protocol
  - Progress in project
  - How long to polish?
- Conclusion and perspective

FACULTÉ DES SCIENCES

universite







## **Requirements for alternative polishing**





DES SCIENCES

Step 3 Untreated Step 1 Step 2 Damaged layer Inclusions Inclusions No-pollution **Bulk Nb** 

#### **Requirements for Niobium:**

- Remove the polluted & damaged layer induced by Nb sheet fabrication ~100-200 um
- 2. Smooth and compataible roughness with EP & BCP (average surface roughness less than 1 um)
- 3. No pollution
- 4. Minor crystallographic damages (stress as low as possible)

# **Requirements for industrialization:**

- 1. Time of treatment should be shorter than conventional
  - polishing (~5 8 hours)
    - => High removal rate ~µm/min.
- 2. Limit manipulations and process to 2-3 steps.
- 3. Polish 2-3 disks at once.





- Motivation for SRF applications (Why polish? Why alternative?)
- Alternative path for SRF cavity fabrication and surface processing
  - Requirements for Niobium
  - Requirements for industrialization
- Metallographic polishing as an alternative technique
  - Polishing protocol
  - Progress in project
  - How long to polish?
- Conclusion and perspective

FACULTÉ DES SCIENCES

universite



#### **Metallographic polishing as an alternative**

ACULTÉ UNIVERSITE PARIS-SACLAY D'ORSAY Université de Paris



# Step 1 &/OR Step 2

**Polishing protocol** 

1. Coarse planarization

CNIS

 Remove the damaged layer due to the rolling of sheets (150 microns).

#### Step 3

- Remove damages and pollution from previous step
- 2. Achieve the final surface

requirement (Sa<= 1 um),

 Limit pollution, minor crystalline damages











## Surface depollution time during polishing

Final polishing step



Contamination is observed after lapping (diamond particles)

Universite

FACULTÉ

D'ORSAY

DES SCIENCES

W

Université de Paris

Chemical-mechanical polishing

is required (colloidal silica)

CNIS

Reappearence of surface crystalline structure





step

0.30

. ຊື່ 0.25

0.20

0.15

0.10 0.05

# Surface depollution time during polishing

5 µm of BCP also efficient to remove the pollution, but not enough to remove damages, also the increases roughness by a factor of 5.



Contamination is observed after lapping (diamond particles)

universite

FACULTE

DODSAV

DES SCIENCES

١Å

Université de Paris

- ➤Chemical-mechanical polishing
- is required (colloidal silica)

CNIS

➢ Reappearence of surface crystalline structure











- Alternative path for SRF cavity fabrication and surface processing
  - Requirements for Niobium
  - Requirements for industrialization
- Metallographic polishing as an alternative technique
  - Polishing protocol
  - Progress in project
  - How long to polish?
- Conclusion and perspective

FACULTÉ DES SCIENCES

universite



- 2-3 steps metallographic polishing recipe has been developed compatible with SRF applications (at IJCLab)
- Surface characterizations show smooth (Sa ~ 100 nm), non-polluted, and minor crystallographic defects
- Polishing procedure extented to the large sheets (at LAM PLAN)
- Forming of 1.3 GHz half-cells with the following cavity fabrication (at KEK)
- RF test measurements are mandatory to evaluate the effect of polishing treatment on Nb for SRF applications (at IJCLab & KEK).

Université de Paris

DES SCIENCES



D'ORSAY



# **THANK YOU FOR YOUR ATTENTION**







Université de Paris

# **Back-up slides**

27/10/2021



27/10/2021



27/10/2021



