A_RD_9
R&D on innovative treatments and characterization of SRF surface for future accelerators.

T. Kubo, T. Proslier

France-Japan-Korea Associated Laboratories
2017 International Annual Workshop

May 11th, Strasbourg
- ILC: ~16000 Superconductive Niobium cavities > 31.5 MV/m = cost driver
- Challenging performance
- Requires a worldwide effort

- Decrease the cost:
  - Multilayer: increase the performances (Emax and Q)
  - Vertical Electro-Polishing
GOAL OF A_RD_09

- Develop process for the large scale cavity production
- From Cavity Fabrication, inner surface treatments, to RF performance Test (Vertical Test: VT)
- Thanks to advanced facilities: CFF/STF/COI at KEK, Supratech at CEA Saclay

- Thanks to motivated teams:

<table>
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<tr>
<th>ID</th>
<th>Title: R&amp;D on innovative treatments and characterization of SRF surface for future accelerators.</th>
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<tbody>
<tr>
<td>Leader</td>
<td>French Group</td>
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<tr>
<td>T. Proslier</td>
<td>Dr.</td>
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<tr>
<td>C. Madec</td>
<td>Dr.</td>
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<td>C. Antoine</td>
<td>Dr.</td>
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<td>S. Berry</td>
<td>Dr.</td>
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<td>C. Servouin</td>
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<td>F. Eozénou</td>
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Vertical Electro-Polishing and multilayers:

- INFRASTRUCTURE
- RECENT ACHIEVEMENTS
- PROPOSAL FOR 2017-2018
Simple VEP setups at Marui Co. Ltd.

- We challenged to make the setups with PVC material for mass production and cost reduction.
- The 9-cell cavity VEP system can be used for VEP of 1-cell cavity also.
- System contains separate pipe lines and pumps for water and EP solution.
- Designed for large cavities
- Circulating acid
- Injected from bottom
- 300L acid capacity
- Cooling system (heat exchanger in acid tank)
- Emptying/draining by gravity
- Nitrogen blowing in top of cavity/acid tank
- Cathode inserted in horizontal position

A simple rod-cathode is used. Low-voltage recipe to reduce hydrogen gas.

SPL Cavity insertion in the cabinet

Cathode’s insertion in horizontal position
ACHIEVEMENTS: NINJA CATHODE 1CELL CAVITY

Ninja Cathode

- There are a couple of advantages in VEP.
- However inhomogeneous removal along with cavity length is usually found and this is a primary issue in VEP.
- Marui Galvanizing developed a unique cathode called Ninja cathode for VEP with 4 retractable wings for agitation and uniform EP over the cavity.

Coupon Cavity

- A coupon cavity was used in order to investigate VEP with Ninja.
- 6 Nb disk type coupons can be set at beam pipes, irises and equator of a single cell cavity.
- The individual coupon EP current is measurable.
- The cavity has also 4 view ports at the top iris, bottom iris and equator for in-situ observation of wings and H₂ bubbles.
ACHIEVEMENTS: STIRRING AND ROUGHNESS

Successful results on Monocellule Nb cavities -> promising for 9 cells

- Almost symmetric removal
- Entire surface smooth and shiny
Two single-cell cavities (NR1-2 and C1-19) were VEPed with the Ninja cathodes and tested in vertical cryostats.

**NR1-2 Cavity (Cornell Cavity)**
- **Pre-treatment**: Tumbling, BCP, degassing at 800 °C
- **Cathode**: Ninja cathodes (partial metal wings and enhance area) with the VEP setup of Cornell University
- **VEP**: VEP with each cathode (20+20 µm removal)
- **Ninja rotation speed**: 50 rpm
- **VT**: Performed at 2K at Cornell after 120 °C baking

**C1-19 Cavity (Saclay Cavity)**
- **Pre-treatment**: BCP
- **Cathode**: Ninja cathode (enhanced area) with Marui VEP setup
- **VEP**: Two VEP for 31 and 55 µm removal, degassing at 750°C and final VEP for 11 µm removal
- **Ninja rotation speed**: 30 rpm
- **VT**: Performed at 1.6K at Saclay

The both cavities showed good performance in the vertical tests.
• Tests of Ninja cathode VEP of 9-cell cavities.
• A coupon cavity was fabricated for VEP parameter optimization.
The 9-cell VEP facility is being improved for better control of VEP condition.

VEP parameter study for a 9-cell cavity is being carried out using the 9-cell coupon cavity and the Ninja cathode.

Optimized VEP parameters will be applied to a 9-cell cavity at Marui and the cavity will be tested in a vertical cryostat at KEK.

Additionally, VEP set up for monocell cavity installed at Saclay (October 2017)

Single cell cavities will be vertically electropolished and tested for evaluation of RF performance at Saclay
Higher Hc of thin-film on Nb → Higher quench field
(Cavity of higher gradient)

Very big impact on ILC.

Multi-layer-thin-film
Single-layer-thin-film

Maximum H on thin-film NbN/I/Nb for various thickness

- Optimized thicknesses of SC and Insulator layers are calculated. T. Kubo. (KEK).
- Numerical simulation TDGL

T. Kubo
CEA/Saclay has lots of experiences for experiments of thin-film samples.

KEK just started experiments for thin-film samples.

Thin-film sample NbN (200 nm)

(Tc of NbN = 16.2 K)

Measured Tc = 13.3 K

Δ(meV)  Γ/Δ(%)  

- Maps of superconducting properties (Δ, Tc, ξ) of alloys and structures
- Large sampling area: up to 1x1 mm²
- Future: visualise vortices.

- AlN/MoN and AlN/NbTiN by ALD on Nb already optimized.
- Coupons -> cavities is trivial
- Future: Integrate oven to existing set up.

Collaboration for thin-film subjects
- Saturation of $H_{C1}$ for NbN > 150 nm. Try thicker films (prediction optimal ~ 150 nm)

- Understanding of vortices transition measured by magnetometry
Why we have two transitions?

- **NbN 200nm, H = 53 mT**

![Diagram showing magnetic field lines and vortex avalanches]

- **First transition**
  - Thin SC layer NbN
  - Insulator MgO
  - Thick SC layer Nb
  - \( H // \) surface => surface barrier
  - A defect locally weakens the surface barrier
  - **1st transition**, vortex blocked by the insulator ~100 nm => low dissipation.

- **Second transition**
  - Propagation of vortex avalanches (~100 µm) => high dissipation.
- Continue measuring penetration fields of various multilayers alloys.
- Correlation with Tunneling spectroscopy.
- Deposition of MoN and NbTiN multilayers by ALD on Nb coupons
- Upgrade the magnetometer (coil and thermal design) to reach higher external fields
- Numerical simulation using TDGL equations to visualize vortex dynamic
### Funding Request from France

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### Funding Request from KEK

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THANK YOU FOR YOUR ATTENTION