RF performances of superconducting coatings on copper for the FCC study


On behalf of FCC RF - WP 3

FCC week 2019
Brussels
“A well-focused R&D programme on Nb thin-film coated Cu cavities could decrease the surface resistance at high RF fields by factors of two to three…”

See FCC conceptual design report @ fcc.web.cern.ch
Different Nb coating techniques

A15: beyond niobium
Energetic condensation techniques are explored

Electron Cyclotron Resonance

High Power Impulse Magnetron Sputtering

RF performances characterized via the quadrupole resonator

\[ R_s = \frac{2\mu_0^2(P_{DC1} - P_{DC2})}{\int_{\text{sample}} |\mathbf{B}|^2 dS} \]

Calorimetric technique
The best Nb/Cu samples in the last two years

Data to be published...

Brussels, June 25th 2019
FCC week 2019
Now, let’s play the game…

Data to be published…

\[ G = 260 \ \Omega \cdot \frac{B_{pk}}{E_{acc}} = 5 \text{ mT/MV/m} \]
Can we replicate on a cavity?

Better substrates are needed

1.3 GHz elliptical cavities

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Conclusions and Outlook

Both HiPIMS and ECR high quality coatings

Both techniques mitigate the Q-slope

Results are still not fully reproducible on cavities

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Beyond

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Source: lapiumablog.com
“The A15 compounds have the potential to outperform niobium…”

- 2020
  - Evaluation of A15-on-Cu samples

- 2021
  - RF tests of A15 on-Cu cavities performed

See FCC conceptual design report @ fcc.web.cern.ch
Two coating procedures by magnetron sputtering

Main coating parameters:

- **Coating gas:** Ar or Kr
- **Coating pressures:** $7 \times 10^{-4}$ mbar ... $5 \times 10^{-2}$ mbar
- **Composition:** Sn 20 At% to 27 At%

Compulsory Annealing

- **Annealing temperatures:** 600 - 800°C
- **Annealing time:** 24 h... 72 h

Alternative Annealing

- **Coating temperatures:** 600 - 735°C
- **Alternative Additional Annealing:** 24 h... 72 h


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A15 phase with Tc as bulk

For more details see:

First RF results are promising

pronounced “Q-slope”

low Tc on QPR sample

$R_s$ (nΩ)

$B_{pk}$ (mT)

$R_s$ (nΩ)

$T$ (K)

$\approx 400$ MHz

Nb$_3$Sn/Nb data taken from S. Keckert et al., SRF2017
The slope increases with both temperature and frequency
Conclusions and Outlook

Good quality of the Nb$_3$Sn coatings

Low residual resistance

New samples are ready for RF tests
Conclusions and Outlook

Good quality of the Nb$_3$Sn coatings

Low residual resistance

New samples are ready for RF tests

There are reasons to be optimistic
Nb/Cu vs bulk Nb for FCC-ee


Courtesy of S. Aull, FCC week 2017
$R_s$ (nΩ)

$B_{pk}$ (mT)

$T=2.5$ K, HiPIMS Nb/Cu

400 MHz
800 MHz
1200 MHz