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SRF Cavities High Q Development for CW Accelerators

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Nitrogen doping is the innovative high Q SRF technology pioneered at FNAL and currently implemented by the LCLS-II project at SLAC. In order to fulfill the high quality factor requirement of this continuous wave free electron laser, the nitrogen doping R&D at Fermilab has been further intensified with aim to deeply understand how ultra-high Q-factors can be maintained throughout all the production chain, from the cavity vertical test to the cryomodule operation. Results will be presented from vertical to horizontal to cryomodule tests.

Cavity horizontal operation introduces a major issue: even after the optimization of the magnetic shielding, some level of remnant magnetic field will always be present during the cool down through the critical temperature. Magnetic field studies performed at Fermilab showed that in cryomodule environments the cavity experiences remnant magnetic field during the cooldown of the order of 5 mGauss, even with advanced shielding techniques. Research is ongoing on how to further reduce these remnant field levels.

We will present studies to address such issues, via efficient cooling and optimization of shielding design. We will show progress on ideal cooling procedures to minimize the magnetic flux trapped at the cavity RF surface. In addition, fundamental studies allowed us to define the best nitrogen doping treatment in order to maximize the cavity quality factor even in presence of trapped magnetic field (via lowering the sensitivity to trapped flux), and then to preserve high quality factors to the cryomodule operation.

We will also show that the nitrogen doping technology is suitable also for future accelerators as PIP-II at Fermilab or FCC, as we have made progress developing N doping at different frequencies like 650 MHz and 3.9 GHz.

Primary author: GRASSELLINO, Anna

Presenter: GRASSELLINO, Anna

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