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Plasma processing under the microscope: a multi-diagnostic investigation from langmuir probes to cryogenic RF tests in low-beta SRF cavities

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Plasma processing has emerged as a powerful tool for restoring and sustaining the performance of SRF cavities over long-term operation. While well-established for elliptical cavities, its application to low-beta structures presents new challenges due to their complex geometries. To address this, we developed optimized plasma processing techniques for a quarter-wave resonator (SPIRAL2 QWR) and a single-spoke resonator (PIP-II SSR1), precisely targeting critical regions such as accelerating gaps and multipacting-prone areas.

Despite the increasing adoption of plasma processing, the underlying plasma parameters remain poorly known. At IJCLab, we conducted advanced numerical simulations alongside direct Langmuir probe diagnostics, marking one of the first in-depth characterizations of the plasma parameters in these cavities. In addition, in-situ quartz crystal microbalance (QCM) measurements quantified the cleaning rate, revealing a strong correlation between plasma parameters and carbon-based surface contamination removal efficiency. To validate our approach, vertical cryostat RF tests were performed on an SSR1 cavity before and after processing.

Our findings provide valuable insights into the effectiveness of our plasma processing approach, representing a major step toward fully optimizing this technique for next-generation SRF systems, both in long-term operation and cavity preparation protocols.

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Yes

Footnotes

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