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Gaseous Electronics Phenomena in Particle Accelerators[1]

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The work is motivated by the development of new compact superconducting RF (SRF) accelerating structures that are capable of producing gradients in excess of 100 MV/m. Compact accelerators and accelerator-based light sources are currently expected to have numerous applications ranging from use in medicine to high-energy physics. However, they require more compact accelerating cavities and components for beam control. Developing and operation of compact particle accelerators involve a multitude of concepts that are analogue to those developed in the traditional disciplines of gaseous electronics. Non-planar, asymmetric superconductor surface treatment using radiofrequency discharges applies techniques that are analogue to those used in the development of planar micro- and nano-electronic devices, although performed on much larger and curved surfaces. During operation, compact particle accelerators behave as pulsed power devices. Just as in the pulsed power devices, it has been reported that all compact concepts are inclined to support the field emission and the multipactor effects that, in turn, limit their range of operation. Multipactor discharge presents a major boulder in the development of compact accelerators and light sources. Multipactor is a resonant discharge generated by the RF field where the growth in the electron density is sustained by secondary emission from cavity walls driven by the RF power that is used for particle acceleration. If more than one electron is emitted for each primary electron, the rate of electron density growth could become high enough to dissipate a significant fraction of the RF power inside the cavity before the saturation due to space-charge or other effects sets in. Using the archived data collection on the performance tests of SRF accelerator components, we identify the relevant gaseous electronics phenomena and their mechanisms. We also review the efforts on mitigation of detrimental effects.

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