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Ferroelectric Fast Reactive Tuner for SRF Cavities – Material Properties and its Applications

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Ferroelectric ceramic materials with low loss tangent at RF frequencies allow development of electrically controlled devices (tuners) with extremely fast switching times (τ<100 ns). This offers the possibility of a Ferroelectric fast reactive tuner (FE-FRT) ferroelectric cavity tuner, operating at room temperature, that can: (1) alter the coupling between the transmission line and the acceleration structure, (2) electronically control the cavity frequency within a bandwidth needed for active compensation of microphonics.

FE-FRTs can be foreseen for a wide variety of RF use cases including microphonics suppression, RF switching, and transient beam loading compensation. This promises entirely new operational capabilities, increased performance, and cost savings for a variety of existing and proposed accelerators.

The ferroelectric material at the heart of FE-FRTs is a BST ferroelectric ceramic, which can be synthesized in the form of polycrystalline ceramic layers and in bulk. Very fast permittivity response times, high dielectric breakdown strength, low gas permeability and simplicity of mechanical treatment make such ferroelectric ceramics an attractive solution for the loading material in fast tuning and switching devices of RF accelerator systems. The material properties of the BST (M) ferroelectric (BST ferroelectric with Mg-based additives, as developed by Euclid Techlabs) in the frequency range 80 MHz −1.5 GHz, have been assessed in terms of applicable material properties, including dielectric constant and loss tangent variations in the 50C −550C temperature range. The results of these measurements are presented here.

The potential for fast reactive tuning with ferroelectric material is presently under development, with CERN considering a potential FE- FRT based beam loading compensation scheme for LHC injection scenarios. Such a use case takes advantage of the fast response time of the ferroelectric material in order to alter the cavity detuning during gaps in bunch trains, which in turn translates to appreciable reductions of required RF power whilst maintaining a constant cavity phase in the presence of transient beam loading.

Primary author: Dr KANAREYKIN, Alexei (Euclid Techlabs LLC)

Co-authors: Dr CASTILLA, Alejandro (Thomas Jefferson National laboratory); MACPHERSON, Alick (CERN); Dr FREEMIRE, Ben (Euclid Techlabs); Dr JING, Chunguang (Euclid Techlabs); Dr BEN-ZVI, Ilan (Brookhaven National Laboratory); SHIPMAN, Nicholas (Lancaster University (GB)); Dr PODDAR, Shashi (Euclid Techlabs)

Presenter: Dr KANAREYKIN, Alexei (Euclid Techlabs LLC)

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