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R&D of scCVD diamond Beam Loss Monitors for the LHC at ultra-cold temperatures

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A Beam Loss Monitor for the LHC provides the most accurate results if it is placed as close to the beam pipe as possible, hence within the cold mass of the magnets. For the new series of triplet magnets, the Beam Instrumentation Group seeks a detector concept that provides full functionality at ultra-cold temperatures (1.9 K). A fast response time, excellent radiation hardness, long durability and reliability, good signal to noise ratio, and a broad dynamic range to cope with a losses differing by orders of magnitude are all critical properties. Obvious candidates for the detector material include single-crystal Chemical-Vapour-Deposited (scCVD) diamond and silicon.

A set-up for Transient Current Technique (TCT) measurements for CVD diamonds at ultra-cold temperatures has been put in place in co-operation with RD39 and the CryoLab at CERN. The set-up provides a good vacuum. A He-Gas cooling device allows for temperatures down to 67 K. Am-241 and Ru-106 sources provide ionizing radiation. Broad-band read-out electronics and a current-sensitive amplifier enable measurement of the transient current.

The presented results are crucial for the future operation of diamonds at cryogenic temperatures. We will present results of measurements of the temperature dependence of fundamental diamond quantities such as carrier drift mobility and velocity, total charge yield, lifetime and detrapping time constants, and trapping energy levels. Furthermore, the difference between MIP-signals and α-signals is shown and important results for possible detector operations are derived. A model capable of explaining the data –the plasma effect with associated trapping –will be presented for the first time for scCVD diamonds. Additionally, pulse shape simulations will show the reliability of the model.

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