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Annealing studies of irradiated p-type sensors designed for the upgrade of ATLAS Phase-II Strip Tracker

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The upgrade for the High Luminosity LHC in 2025 will challenge the silicon strip detector performance with high fluence and long operation time. Sensors have been designed and tests on charge collection and electrical performance have been carried out in order to evaluate their behavior. Besides that, it is important to understand and predict the long-term evolution of the sensor properties.
In this work, we present detailed studies on the annealing behavior of ATLAS12 strip sensors designed by the ITK Strip Sensor Working Group and irradiated from 5*10ˆ13 to 2*10ˆ15 n_eq/cmˆ2. Systematic charge collection, leakage current and impedance measurements have been carried out during the annealing time at 23 and 60℃ until break-down or the appearance of charge multiplication. Sensors showing charge multiplication have been then kept at high voltage for a long time in order to monitor their stability.
The difference in the annealing behavior between the two temperatures has been analyzed. From the impedance measurements for the samples irradiated to low fluences it was possible to extract the effective doping concentration. This was compared to similar measurements on n-type sensors and with a theoretical model.
The results show that ATLAS12 sensors anneal similarly to the previously designed ATLAS07 and the behavior is well described by the theoretical model. Nevertheless, a significant difference on the time constant of the beneficial and reverse annealing has been reported, especially at lower temperatures. For the highest fluences and longer annealing time, e.g. 5000 minutes at 60℃, charge multiplication has been observed. The phenomenon is however temporary and disappears with the long-term voltage stress.

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