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Temperature and frequency dependent CV measurements of highly irradiated ATLAS strip detectors and diodes for impedance spectroscopy

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For medium and highly irradiated silicon devices such as strip detectors or diodes it has been observed that the commonly used CV method for deriving depletion voltage as well as doping level is not as easily applicable as for unirradiated devices. The reason for the arising difficulties is that defects created in silicon can capture and release charge carriers and therefore show a time dependency which affects the CV measurement. To be able to measure highly irradiated sensors a setup has been designed and assembled which enables a CV frequency variation down to 20Hz and temperature control to get down to -20 to -40℃ to investigate the influence of the defects superimposing the geometrical behaviour of the devices. With the measured data an impedance spectroscopy has been performed to differentiate between a capacitive (the ideal case) and a resistive behaviour which allows a determination of an effective time constant for the defects present. Lowering the temperature offers the possibility to increase this time constant according to Boltzmann's law, and by this an effective energy depth of trap levels can be calculated.

Comparison with unirradiated devices indicates the effects introduced by radiation damage and comparison of diodes with strip detectors shows the role of the segmented front side.
As expected, strip detectors show at high frequencies a deviation from a pure capacitive behaviour which can be explained by the RC element caused by bias resistors. For unirradiated devices no temperature dependence is observed as it would be expected for a constant resistance whereas for irradiated sensors we observe a strong temperature dependece which can only be explained by either a temperature dependent resistance or some interaction with defects in the silicon.
Furthermore, it is shown which frequencies of the CV measurements are an optimal choice for different analysis goals like doping or effective energy depth determination.

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