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Hot spot visual evaluation of breakdown locations in ATLAS18 ITk strip sensors and test structures

An important characteristic of silicon-based particle detectors, like those used for the forthcoming ATLAS ITk upgrade for the HL-LHC, is the leakage current. This characteristic is evaluated in the quality control stage of the new ITk strip sensors performing an IV measurement, where the sensors are biased up to -700V, typically showing low and stable leakage current. However, some sensors can exhibit a sudden leakage current increase during the IV measurement, so-called early breakdown, making the sensor unusable.

The analysis of these early breakdown conditions typically consists of visual inspection of the sensors using a microscope, as often this is caused by physical damage, be it a deep scratch, chipping on the edges of the sensor, or other damage. But up to this point, the association of the observed damage with the early breakdown is not definitive. Rather, this is an association by correlation, due to the limits of verification by observation with standard equipment.

A hot spot imaging setup has proven to be a valuable diagnostic tool to identify and understand these early breakdown conditions and elaborate on former understandings of these emissions. The regions responsible for the breakdown can be properly located by imaging the infra-red light emissions produced by them in breakdown conditions. These regions of interest can also be imaged at magnification to evaluate the more precise structure of the breakdown to better understand the damage. The regions discovered, which have improved our understanding of breakdown damage and its symptoms, include scratches, chipping, static charge buildup and manufacturer defects in the ATLAS18 strip sensors and test structures.

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