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Steady-State Method to Measure the In-Plane Thermal Conductivity of Thin Sheet Materials.

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ABSTRACT

A new generation of silicon pixel detectors is required to cope with the unprecedented luminosities at the high-luminosity phase of the Large Hadron Collider (HL-LHC) in 2025. The HL-LHC provides a high radiation, high interaction rate environment for the innermost detector region of the CMS detector. This can lead to an uncontrolled increase in temperature of the detector that can destroy the silicon pixels. Moreover, too high operating temperature can add noise to the data obtained from the detector and can slow the read out cheap down. Therefore, the Phase II upgrade to the Compact Muon Solenoid (CMS) experiment requires an improved heat removal scheme. This challenge can be solved by using carbon fiber as one of the materials for silicon detector support structure. This material has relatively high thermal conductivity and structural stability. To properly simulate the behavior of a support structure in the experiment environment, it is crucial to know the thermal conductivity of these materials. The thermal conductivity of carbon fiber is anisotropic, meaning that it is different for different directions through the material. Therefore, we measure the thermal conductivity along and perpendicular to the fibers. To measure the in-plane thermal conductivity of thin sheet carbon fiber, the "steady-state" method is employed. The validation of the apparatus is done with two materials of known conductivity. In-plane thermal conductivity measurements of several thin carbon fiber sheets are performed. Measurement results show the Carbon Fiber K13D2U thermal conductivity of 515 W/mK in the plane and along the fiber.

KEYWORDS

Detector design, silicon detector, materials, carbon fiber, thermal conductivity, high-precision calibration.