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A Packaging Method for ALPIDE Integration Enabling Flexible and Low-Material-Budget Designs

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This work presents a novel, patent-pending solution for the packaging of ALPIDE chips that facilitates non-planar assembly with a minimal material budget. This solution represents an advancement based on methodologies developed for the ALICE ITS1 and the STAR tracker two decades ago. The core of this approach involves the use of flexible cables composed of aluminum and polyimide, with thicknesses on the order of tens of micrometers. These cables are connected to the sensors using single-point Tape Automated Bonding (spTAB), which replaces the traditional wire bonding technique that is suboptimal for curved integrations. The spTAB bonding is achieved by creating openings in the polyimide layer, allowing aluminum wires to remain free-standing, which are then connected to the sensor using pressure and ultrasonic energy. Extending this concept, we have applied this approach to entire printed circuit boards (PCBs), resulting in a fully flexible packaging solution maintaining an ultra-low material budget. This work introduces a prototype utilizing this method to bond an ALPIDE chip, proposing it as a viable option for future designs necessitating flexible packaging for both the chip and associated electronics. The overall workflow, comprising microfabrication and assembly, is carried out in the Fondazione Bruno Kessler laboratories and will be detailed to elucidate our procedures and demonstrate the applicability of our solution in future experimental setups. The proposed packaging features a flexible PCB constructed from three stacked layers, each containing 20 μm thick aluminum features and a 25 μm thick polyimide substrate. These layers include a ground layer, a signal layer (encompassing both digital and analog signals), and a bonding layer (which substitutes wire bonding). The spTAB technique is employed for inter-layer connections within the PCB and for sensor bonding. We will discuss the performance of transferring both digital and analog electrical information through the flexible PCBs. SEM and PFIB optical characterizations, along with pull-test measurements to qualify the bonding, will be reported. Furthermore, we will quantitatively assess the flexibility of the entire assembly (ALPIDE and flexible PCB) and describe the behavior of the spTAB connections when the device is bent to a curvature radius of a few millimeters.

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