Contribution ID: **160** Type: **Poster**

Flexible PCBs for modern chip integration at FBK: ALPIDE chip as case study

Thursday 3 October 2024 17:40 (20 minutes)

The use of ultra-lightweight flexible Printed Circuit Boards (PCBs) in silicon-based particle detectors was pioneered for the ALICE Inner Tracking System 1 (ITS1) and the STAR tracker in the early 2000s. These PCBs feature thin, flexible interconnections made of µm-scale polyimide (e.g. kapton) and metal (e.g. copper or aluminum), offering low-mass yet with stability of mechanical and electrical properties. However, decreasing feature sizes by keeping a low percentage of defects and dimensions close to nominal values requires high process control and sustained quality control efforts. This study introduces innovative microfabrication approaches and systematically characterizes thin flexible PCBs mechanically and electrically.

Summary (500 words)

This study presents the research and development conducted at Fondazione Bruno Kessler (FBK) in Trento, Italy, focusing on the microfabrication of ultra-thin and flexible Printed Circuit Boards (PCBs) for advanced sensor packaging and integration in particle physics applications. The presentation will detail the PCBs manufactured at FBK using Kapton and Copper or Aluminum, emphasizing key production and integration challenges with the chip. Various bonding techniques compatible with the presented technology (e.g. wire bonding, tape automated bonding, ball-bonding) will be discussed. The ALPIDE chip will serve as a case study to demonstrate the promising outcomes of integrating ultra-thin chips with flexible PCBs. The PCBs fabricated at FBK consist of 50 µm thick Kapton as the dielectric material and 25 µm thick copper or aluminum as the conductive material. The entire microfabrication process takes place within the FBK cleanrooms. Comprehensive quality inspections utilizing PFIB and SEM techniques are conducted to examine micro features and analyze defects, with detailed findings to be documented. A grain-level investigation of the conductive material is performed using electron backscattered diffraction (EBSD) technology, highlighting the relationship between grain geometry and the electrical properties of the patterned micro features on the substrate. Additionally, a series of 12 ALPIDE chips bonded to the flexible PCBs are utilized to gather statistical data on the electrical performance of the substrates. The presentation will also include multilayer PCB configurations. The bottleneck in the technology involving ALPIDE chips pertains to M-LVDS (multipoint low voltage differential signaling), integrated into the chip by TowerJazz for digital communication and clock transmission purposes. Significant emphasis has been placed on the microfabrication of these differential pair lines, ensuring an optimal design configuration for signal integrity. A challenging aspect concerns the characteristic impedance of these lines, which must precisely match the additional impedance employed to terminate the lines, ensuring optimal signal integrity. Achieving this level of control is complex and could result in non-reproducible characteristic impedance across different batches. FBK has developed a method to address this challenge, employing a combination of tailored high-quality etching strategies to achieve optimal reproducibility in microfabrication, with variations of less than 10%. The presentation will also address the flexibility of these PCBs. Modern particle physics experiments increasingly require bent chip solutions to accommodate the beam pipe, where particle bunches traverse at LHC. This engineering challenge is highly complex, prompting significant research and development efforts in this area. Flexible chips like ALPIDE, thinned to 50 µm, enable direct silicon integration. Consequently, the electrical integration of such chips must also be flexible. The results of bending ALPIDE+Flex PCBs will be presented, including variations in analog current driven by the chip when the sensor is bent.

Authors: LEGA, Alessandro (INFN); Mr PEDRIELLI, Andrea (Fondazione Bruno Kessler); NOVEL, David; RICCI, Ester (Universita degli Studi di Trento and INFN (IT)); BELLUTTI, Pierluigi (FBK); IUPPA, Roberto (Universita degli Studi di Trento and INFN (IT)); Prof. BEOLE, Stefania Maria (Universita e INFN Torino (IT)); FACCHINELLI, Tiziano (Fondazione Bruno Kessler)

Presenter: LEGA, Alessandro (INFN)

Session Classification: Thursday posters session

Track Classification: Packaging and Interconnects