Contribution ID: **64** Type: **Poster Presentation**

Interconnect and bonding techniques for pixelated X-ray and gamma ray detectors

Wednesday 10 September 2014 14:00 (1h 40m)

In the last decade, the Detector Development Group at the Technology Department of the Science & Technology Facility Council (STFC), UK, established a variety of fabrication and bonding techniques to build pixelated X-ray and gamma ray detector systems such as the HEXITEC detector for imaging and spectroscopy [1]. The fabrication and bonding of such devices comprises a range of processes and techniques including material surface preparation, detector pixelation by means of photolithography, stencil printing, flip-chip and wire bonding of detectors to application-specific integrated circuits (ASIC). This paper presents interconnect and bonding techniques used in the fabrication chain for pixelated detector assemblies at STFC.

Individual detector dies (~20x20mm²) and raw material such as cadmium zinc telluride (CZT) crystals can be cut with a diamond wire saw to the required thickness (usually 1mm to 5mm). Subsequently anode and cathode surfaces are lapped and polished to a mirror-finish. Electroless gold deposition and lithography are used for forming typically 74 x 74 arrays of 200 x 200 μm² pixels with 250 μm pitch on such prepared detector surfaces. Due to a lack of availability of CZT wafers, lithography is commonly carried out on individual detector dies which represents a significant technical challenge as the edge of the pixel array and the surrounding guard band lie close to the physical edge of the crystal. The fabrication of these detectors from single die is an important first step towards the tiling of detectors into larger arrays [2].

In the case of the HEXITEC system which has pixels on a 250 μm pitch, detectors are flip-chip bonded to the readout ASIC using a gold stud and low-temperature curing silver-loaded epoxy technique. These assemblies are then wire bonded to a PCB module that can be mounted and demounted to the data acquisition system. Using low-temperature curing epoxy allows us to keep CZT crystals at temperatures T <45℃ in this bonding process which minimizes adverse effects such as migration of tellurium atoms in the crystal.

For detectors with pixel size far less than 200 x 200 μm², the silver epoxy bonding technique is unsuitable due to limitations in the minimum bond size. To allow smaller pitch detectors to be bonded, STFC have recently developed a compression cold-weld indium bump bonding technique. A photolithographic lift-off technique is used to form indium bumps on both the detector and ASIC which are then flip-chip-bonded with the application of <1 g per bond. Results of this new technique for bonding detectors will be presented.

[1] M.C. Veale, J. Kalliopuska, H. Pohjonen, et al., "Characterization of M-π-n CdTe pixel detectors coupled to HEXITEC readout chip", JINST 7, C01035 (2012)

[2] Matthew D. Wilson, Steven J. Bell, Robert J. Cernik, et al., "Multiple Module Pixellated CdTe Spectroscopic X-Ray Detector", IEEE TRANSACTIONS ON NUCLEAR SCIENCE 60, 1197-1200, (2013)

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Session Classification: Session 10: Posters 1 (Particle Physics, Pixel Detectors and Lifesciences)

Track Classification: X-ray and gamma ray detectors