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Development of the probe station for the hybrid assemblies of the European XFEL camera AGIPD

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The European XFEL facility delivers bunches of high brilliance pulses with a unique time structure, which requires a specially designed photon detectors for taking and recording the high quality scientific data. The Adaptive Gain Integrating Pixel Detector (AGIPD) is a hybrid pixel X-ray detector developed to cope with crucial requirements like 4.5 MHz frame rate and a dynamic range of 10⁴ 12.5 keV-photons. An important part for the data quality is the hybrid front-end module and its yield. In order to improve it a special probe station was designed and commissioned, the challenges and results are to be reported.

Summary (500 words)

The experimental stations of the European XFEL offer a possibilities for conducting the cutting edge physical experiments using original properties of the source, which include a burst operation with the bunch trains containing 2700 pulses of >1012 photons of 12 keV each, separated by 220 ns. This cycle is repeated at the rate of 10 Hz. Those properties put a challenging requirements on the detectors for the experimental stations of the facility. The AGIPD detector was developed to fulfill the requirements of the SPB and MID instruments including the following key features: a high dynamic range - from single photon sensitivity up to 104 12 keV photons, a fast frame rate of 4.5 MHz and a memory for 352 usable images in burst operation. Also the radiation tolerance of several 10 kGy was taken into account.

The AGIPD is based on a hybrid technology, including a sensitive surface consisting of a semiconductor pixel sensor and 16 ASICs attached to it using bump bonding technique. This assembly (further hybrid) is glued and wire bonded to the Low Temperature Co-Fired Ceramic (LTCC) board and mechanically connected to the copper interposer. This multilayer unit called a front-end module (FEM) is an essential part of the detector for the quality of the data.

As any component this unit has its own yield based on different factors and it had a rate of ˜52%, which is not enough for the successful production of FEMs, taking into account that a newer systems should be designed as double modules reducing the yield even further.

In order to improve the FEM yield an extensive study on yield killers was done and it showed that there are 4 main sources of imperfections for the FEM production exist:

• the ASIC quality after the bump bonding
• sensor quality after the bump bonding
• bump bonding process itself
• unacceptable sensor dark current, which originates from the poor thermal contact between the hybrid and the cooled copper interposer.

In order to reduce the first three mentioned above factors a special probe station for the hybrids was developed. The station includes a custom designed cantilever probe card for probing of 480 ASIC read-out pads and also providing the high voltage to the sensor with 4 pins. The probe card is attached to the specifically manufactured probe holder and to the read-out board. For the probing the DUT is pushed up to the probe card, powered and then being read out.

The special testing methodology of probing was developed and implemented resulting in eliminating the factors regarding the quality of both ASICs and bump bonding process. The sensors are tested by the hybrid manufacturers and then are being tested once more during the probing. All mentioned error sources are thus screened and any bad hybrid is to be rejected or reworked. The poor thermal conductivity is to be improved by use of the flattest LTCCs and better thermal filling with an expectation of yield improvement up to ˜80%.

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