Sensor testing of Intermediate Silicon Tracker

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The Intermediate Silicon Tracker (INTT) uses a multichannel silicon sensor to record tracks of charged particles. The characteristics of all channels should be measured to determine the performance before assembly. Some coarse quality assurances of every sensor are made by Hamamatsu Photonics K.K. before delivery, including total IV and CV measurements of combined multiple channels. Individual channels are then tested at the National Central University (NCU) in Taiwan.

A half ladder of the INTT detector has 26 chips, and each chip has 128 channels. If we use a micropositioner to touch the sensor channel by channel, the measurement time will be huge. Furthermore, in this method, it is difficult to control the touch force on AC pads, resulting in severe damage to the pads. A major scratch on an AC pad can cause a fatal problem in the wire bond to the pad in an assembly process. The best solution is to use a probe card to connect 128 channels simultaneously and then pass through the relay matrix to scan each channel. We only need to raise the voltage once in one chip and keep the voltage to measure other channels. To avoid severe scratching on bonding pads in this testing process, we employ a probe station (MPI TS200) that can control the contact force of the probe. When height is defined, the repeatability of the machine is smaller than 2 μm, and the contact force is controlled by a machine, rather than a human hand. Because INTT silicon sensors have an AC-coupling design, all of the leakage current originating from silicon will be blocked by a capacitor between silicon and the readout metal. The most important measurement is, thus, the capacitance of each channel for the AC-coupling silicon sensors. To measure the capacitance, the silicon sensor should be fully depleted.[1] In the AC-coupling silicon sensor structure (Fig. 1), the AC pads and silicon are isolated; therefore, we need a contacting bias ring to create a closed circuit to ensure full depletion. However, using a probe card to touch the readout pads and bias ring together is difficult because the contact window only opens at four corners of the full sensor. Therefore, the coordinates of the window are not constant for each chip. Now, we change the connection to the DC pad to 0 V create a circuit. In the first study, the capacitance difference is only 0.5 pF between the connections to the bias ring and DC pad. CV curves (Fig. 2) and the channel distribution of capacitance (Fig. 3) measured with two methods in one chip show almost the same behaviors, thus suggesting that the DC pad provides a reasonably consistent 0 V contact point as the bias ring with an extra offset of ~0.5 pF. Figure 3 shows that the capacitance is independent of which channel is connected to 0 V; therefore, a one-pin connection to the DC pad should be sufficient. Therefore, the probe card will have 129 pins: 128 for the measurement of the AC readout and one for the DC pad. Subsequently we can determine the existence of bad strips on the sensor and mark them.

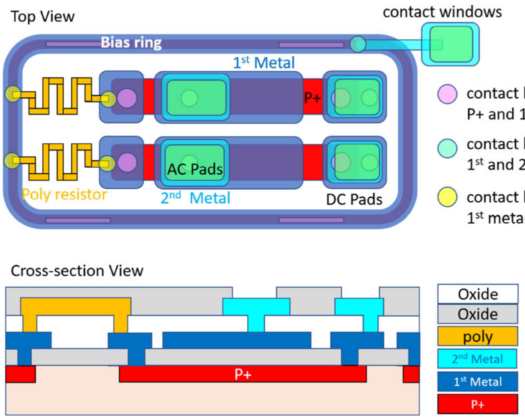

Fig. 1. Schematic of the AC coupling sensor.

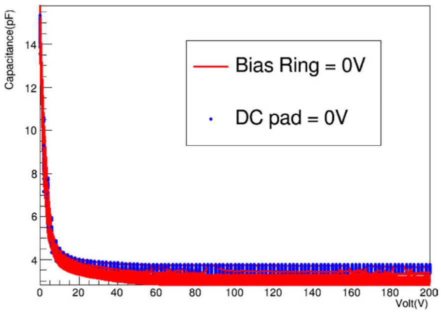

Fig. 2. CV curves of all channels in one chip. The blue markers show the result of connecting the DC pad to 0 V, and the red lines show the result of connecting the bias ring to 0 V.

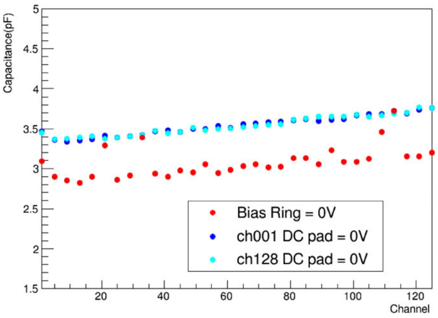

Fig. 3. Channel distribution of capacitance at full depletion. The red circles show the values obtained with the bias ring connected to 0 V, the blue and cyan circles show the value with the DC pads of channel-1 and channel-128 connected to 0 V.

Reference

1) R. Nouicer *et al.*, Nucl. Instrum. Methods Phys. Res. A **461**, 143–149 (2001).

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