Sensor Specification and Quality Assurance Testing

Sensors

The silicon sensor is a 7.5 degree wedge comprised of two columns of mini strips. Each column of strips is read out independently, on the left or right side of the sensor. The strips approximate a 3.5 degree arc in phi. The length of the strip is a function of radius. For example, the strips on the large wedge are 3.45 mm long at the inner radius, and they continuously lengthen with increasing radius, reaching 11.2 mm length at the outer radius. The strip pitch is 75 μm in the radial direction. There are 640 strips per column on the sensors in the two forward-most disks, and 1664 strips per column in the remaining six disks. The radial length of the small wedges that comprise the two forward-most disks is 49.90 mm (1.96 ") and 126.53 mm (4.982") for the remaining six disks. The large wedges must be processed on 6-inch wafers if they are to be fabricated in one piece. We have identified three vendors with 6-inch wafer processing capability. The crystal orientation of the wafer stock is either <111> or <100>, depending on the vendor selection. The sensor is 300 μm thick. The wafer resistivity, which is inversely proportional to the depletion voltage, is 2.0 to 5.0 kΩ, corresponding to depletion voltage less than 100V. Operating voltage is defined as 50V + depletion voltage. The starting material is n-doped bulk with p-type implants. The backside of the detector is aluminized. The detector bias voltage is applied to the backside. The strips are at ground potential. The strips are ac-coupled on the sensor. The capacitor is made by depositing an oxide layer of approximately 200 nm on top of, and over the entire length of the p-implant. An aluminum metallization is placed on top of the oxide to complete the capacitor and to form the readout conductor. The bias connection to the p-implants is made by a polysilicon resistor of approximately 1.5 MΩ, which is electrically connected to a common bias ring on one end, and to the p-implant on the other end. There is an individual polysilicon resistor for each strip. There are three sets of pads on each strip. There is a spy pad which penetrates the oxide layer to allow probing of the dc characteristics of the strip. There are probe pads, which are dedicated for probing the ac characteristics of the strips. And there are bond pads which are only used to wire bond from the detector to the electronics. All non-metal surfaces of the top side of the sensor are covered with a passivation of silicon-oxide or silicon-nitride. A guard ring is implanted around the perimeter of the wedge between the bias ring and the cut-edge of the sensor to prevent breakdown at the cut-edge of the sensor under a normal range of bias voltage. The sensor breakdown voltage is specified to be ≥200V or ≥50V+ operating voltage, whichever is greater. There is no need to specify higher breakdown voltage, or to incorporate multiple guard ring structures, because the anticipated integrated 10 year radiation dose of 200 krads does not require it. Leakage current at 20˚ C is specified to be ≤ 160 nA/cm^2 at operating voltage. All of these processes and specifications are standard in the industry.

Production will be made in two stages. First, a minimum lot size to evaluate the process, followed by production of the balance of the order. It is assumed that the small wedges and the large wedges can be incorporated together on a single mask. We believe that 3 large wedges and, more small wedges than we need, will fit on one mask.

We require 288 large wedge sensors + 42 spares = 330 sensors
We require 96 small wedge sensors + 24 spares = 120 sensors

The numbers above suggest an order of approximately 110 wafers.

Quality Assurance

The vendor is required to perform basic quality assurance (QA) tests and to provide the purchaser with the test data. The specifics of these tests vary from vendor to vendor, and are finalized through the purchase contract. Typically the vendor QA tests for each sensor include:

1) visual inspection to identify processing or handling flaws
2) current versus voltage characteristic curve for each sensor
3) capacitance versus voltage characteristic curve for each sensor
4) full depletion voltage and breakdown voltage for each sensor
5) coupling capacitor integrity or short for each strip
6) implant open or short for each strip
7) polysilicon resistor open or short for each resistor

On receipt, all sensors will be stored in a clean, temperature and humidity controlled environment. For the prototype and, at least, for the first batch of production detectors, all 7 of the QA procedures above will be repeated in our laboratories. For the prototype and production QA tests, assuming 80 sensors within a prototype run, and 450 sensors for production, including spares, we have allotted an average of more than 6.0 hours of QA testing per sensor. This is adequate to do the full testing of each strip on each sensor. If the quality of the prototypes and the first batch of delivered sensors are such that the vendor's test data is validated by our own tests, we might choose to scale back the tests on individual strips, and sample a set of strips on each sensor. We always perform all the global sensor tests. All test results are normalized to 20˚ C.

Facilities and Manpower

The UNM collaborators and the Prague Group have instrumented probe stations in clean rooms where sensor QA tests can be performed. Nevis Labs has requested internal funding from Columbia University to upgrade their clean room and if successful, will also contribute to the QA effort. Experienced staff, Doug Fields, UNM, Jon Kapustinsky, LANL, and Vaclav Vrba from the Prague Group will be closely involved in the initial QA tests. Students will perform the bulk of the QA tests once the procedure has been deemed routine. UNM and the Prague Group have students who are trained to operate a probe station and perform QA tests. We have budgeted approximately 3 student-years of effort over 6 months of production testing. A probe station is effectively run by one person at a time.