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CALIBRATING THE THREE FUNCTION MERCURY PROBE

For optimum measurement results using the MDC Mercury Probe, careful calibration of the probe contact diameter and stray capacitance should be performed. It is best to calibrate the Mercury Probe using a standard that is similar in configuration to the samples that will be measured. This means that standards based on both bare wafers and oxide coated wafers may be used. The current release of the Mercury Probe Operator's Manual discusses calibration with a bare wafer. Techniques for calibration with an oxide coated wafer are given here.

CALIBRATING THE THREE FUNCTION MERCURY PROBE WITH AN OXIDE STANDARD

A STANDARD

Use a standard wafer or a set of standard wafers for calibration of the Mercury Probe. The optimum standard to use is one of similar diameter, thickness, type, oxide thickness, and doping/resistivity to the wafers to be measured.

A heavily doped silicon wafer with a calibrated oxide thickness of approximately 1000 Angstroms is a good general choice.

GENERAL CALIBRATION PROCEDURE

The steps to be followed for a Mercury Probe calibration are outlined in this section and discussed in more detail in following sections. The main steps are:

1. Setup the capacitance meter. Make sure that the frequency, cable length, and zero compensation are set properly.
2. Clean and prepare the Mercury Probe measurement platform and the standard wafer.
3. Estimate the stray capacitance.
4. Contact the standard wafer with the probe.
5. Output positive and negative voltages. Determine the accumulation capacitance.
6. Compute the area of the mercury dot from the accumulation capacitance

CAPACITANCE METER SETUP AND CONNECTION

If the capacitance meter has multiple frequency capability, set the frequency of operation to the desired value. Make sure any cable settings are proper for the connection between the capacitance meter and the Mercury Probe. Select the Mercury Probe configuration used for calibration to be the same one that will be used for measurement. Do not calibrate in one configuration (i.e. Front-Front) and measure in another (i.e. Front-Back). Zero the capacitance meter with the calibration wafer in place and with the Mercury Probe Control Arm in the Purge position.

WAFER PREPARATION

Use compressed air or nitrogen to blow off any particles on the standard wafer and the measurement platform. If using the Front-Back configuration, remove oxide on the backside of the wafer to insure a good ohmic contact. A drop of deionized water on the back of the wafer will also improve contact resistance in the Front-Back configuration if the wafer is not metallized. Do not use any water in the Front-Front configuration.

ESTIMATE THE STRAY CAPACITANCE

Calibration of the Mercury Probe using an oxide coated wafer cannot be used to precisely determine the stray capacitance. Precise determination of the stray capacitance can only be accomplished using the bare wafer calibration method. If it is not feasible to use a bare wafer, a method for stray capacitance estimation is given here.

With the wafer in place and the Mercury Probe Control Arm in the Purge position, zero the capacitance meter. Watch the capacitance meter and slowly move the Control Arm to the Measure position. The capacitance meter will jump to a capacitance in a range of 1 to 2 pF. This capacitance is the stray capacitance estimate. The capacitance will remain at this level for a few seconds before increasing to the MOS device capacitance.

WAFER MEASUREMENT

The Mercury-Oxide-Semiconductor (MOS) device has a capacitance that is voltage dependent. For an accurate computation of the mercury dot area, the accumulation capacitance must be found. Use a computer-controlled MOS device measurement program or change the bias manually to find the accumulation capacitance. The accumulation capacitance is usually the largest capacitance that is measured for an MOS device that is not leaky. Typically, the accumulation capacitance is reached by biasing the device with a voltage of approximately $\pm$Tox/200, where Tox is the oxide thickness in Angstroms. Use a positive voltage for n-type substrates and a negative voltage for p-type substrates. Verify that the accumulation capacitance has been reached by increasing the voltage by a volt, or two. The capacitance change should be small.

Note that several factors can affect the accuracy of the accumulation capacitance measurement. Series resistance errors from a high resistivity substrate or poor backside contact can introduce large errors. Leakage can also distort the measurements. Choose a sample that will minimize error sources or apply all possible corrections to offset the errors.

AREA COMPUTATION

Find the mercury dot area using the following equation:

$$A = \frac{C_{ox} T_{ox}}{\varepsilon_o \kappa_{ox}}$$

where:

A = the mercury dot area, in cm^2

C_{ox} = the accumulation capacitance, in Farads

T_{ox} = the oxide thickness, in cm

ε_o = the permittivity of free space, 8.854E-14 Farads/cm

κ_{ox} = the relative permittivity of the oxide, 3.84 for SiO_2.