Manual Spreading Resistance measurement System.

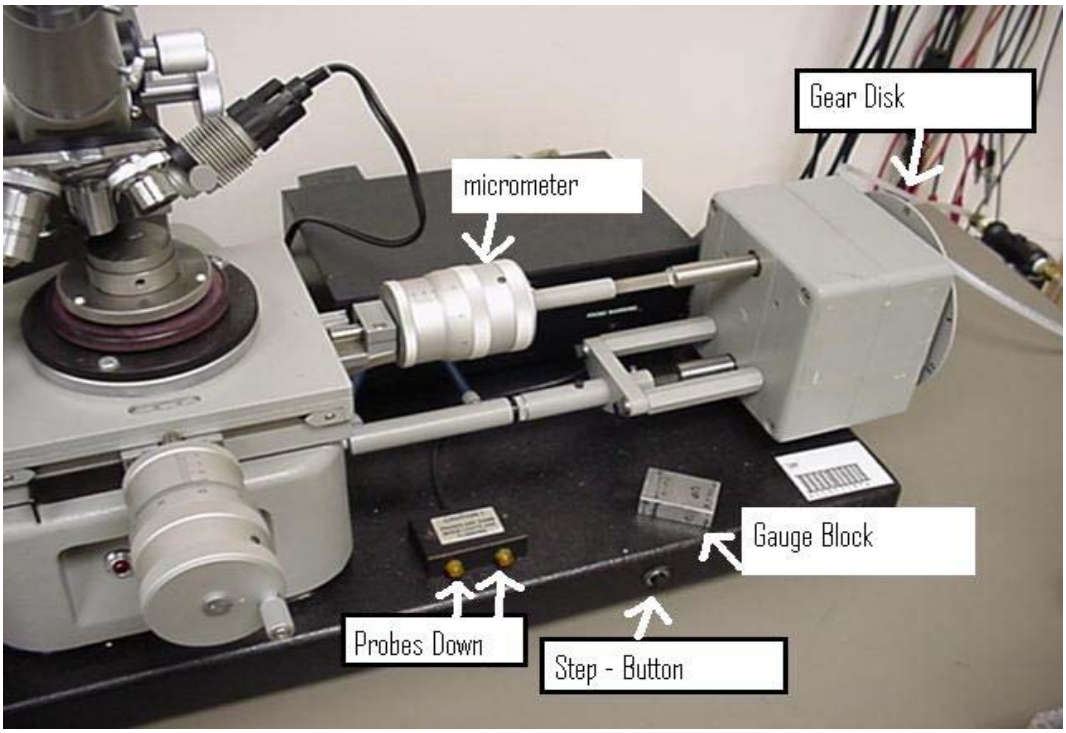

Fig. 1: SSM130 Spreading Resistance Measurement System.

The spreading resistance measurement system (SRMS) is normally used to determine active doping profiles in semiconductor materials. It can also be useful to determine the film thickness of a thin film. It measures the electrical resistance of a sample along a polished bevel. As the two electrodes are very close together only the local electrical resistance is measured (the spreading resistance). A schematic picture of the measurement technique is given in Fig. 2.

The gray area, the beveled surface, is normally created by polishing the sample with diamond paste on a glass plate. The electrodes are stepped along this surface and measure the local resistance. Data gathered on the left side of the bevel represent information deep in the wafer while data gathered at the right side of the bevel represent the active doping concentration near the surface of the wafer. Typical bevel angles are smaller than 1 degrees.

As the spreading resistance measurement technique is a two electrode technique, the condition of both electrodes is very important. The electrodes are not single point contacts (as for example an scanning tunneling microscope) but each electrode is supposed to create a whole collection of micro-contacts with the silicon wafer. Those

microcontacts are created by asperities (roughness) of the tips. In order to be able to interpret the measurement results it is important that the electrodes have a certain well defined roughness. Conditioning is the process of creating the right distribution of asperities on the electrodes. It is done with a Gorey-Schneider probe grinder. This probe grinder uses 1-micron or 25-micron diamond paste to "roughen" the tips of the electrodes. Once the probes are conditioned they must be stabilized and tested on the QTA-sample (Qualification, Test, and Alignment triangular shaped) to ensure that they meet specifications.

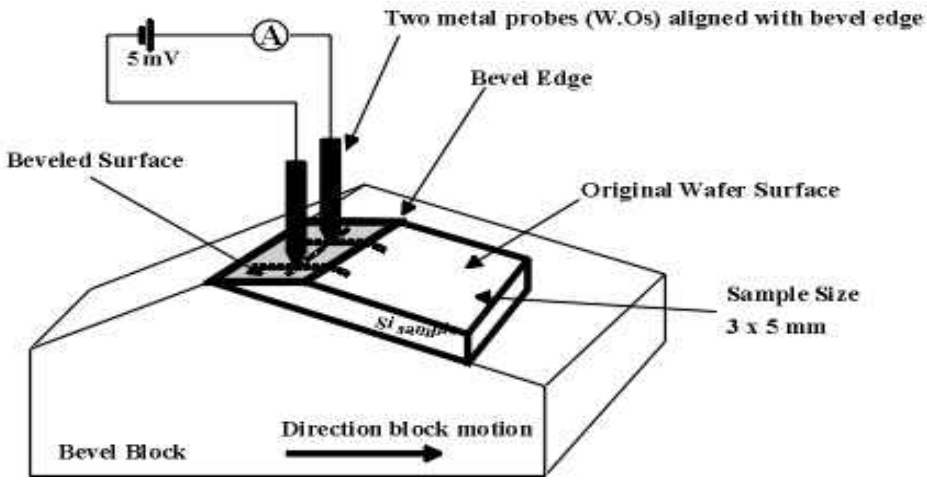

Fig. 2: Measurement principle: Bevel block (chuck) with sample; two electrodes; low voltage.

Since the spreading resistance technique uses only two electrodes, it is important that your measurement results are compared with the measurement results of standards that resemble the sample you are investigating. A whole series of standards are available.

This document will only explain how to polish and mount a sample and how to perform a standard measurement. For information on how to condition the probes see ProbeConditioning.doc. For information on how to calibrate the equipment see Callibration.doc.

Mounting the sample:

1. A typical sample for the SRMS is 1/8"x1/4". The sample is mounted with wax on a beveled block (=BB). There are several BBs available. The angle of the slope is written on the back. For thin samples you choose a low angle slope, and for thicker samples you choose a larger angle slope.
2. Place the BB on the 2200 Thermolyne hotplate. Put the hotplate on 250 and preheat it for 5 minutes. While the hotplate is heating up, clean your sample with acetone to ensure that there is no pieces of broken semiconductor adhering to the bottom of the sample
3. Melt a piece of wax (brown) on the BB to mount the sample. To apply the wax simply touch the wax bar to the hot BB. Line the short side of your sample up with the "roof-top" of the BB (see figure 2).
4. Switch off the hotplate.

5. Remove the BB from the hotplate with a pair of tongs. While the sample is still hot, blot it with a tissue that has been folded several times to keep the wax from seeping through to your hand. This will remove excess wax and ensure that the sample is mounted flush with the BB. Make sure you do not move the sample. Push the sample against the BB and remove excess wax.
6. Let the BB and mounted sample cool down for 5 minutes.
7. Clean the sample and BB with acetone. Remove excess wax as we do not want wax on the polishing glass.

Polishing the sample:

1. The bevel is polished by using diamond paste and isocut fluid on a glass plate. Locate the circular track polisher.
2. The circular track polisher consists of a lapping/polishing jig, an arm, a frosted glass plate, and a square plastic container. The lapping/polishing jig consists of piston that fits in a cylinder. Push the piston almost all the way out of the top of the cylinder and set the cylinder on its feet on a flat surface. Check the time needed for the piston to fall to the surface under its own weight. This should be approximately 5 to 15 seconds. If the piston falls too quickly, apply damping grease to the cylinder (apply the grease with the wood-side of a q-tip). Be sure to apply the grease evenly over the piston. If it falls too slowly, wipe off a small amount of the grease. Be careful because the grease contains lead. So please wear gloves and wash your hands after your done.
3. Apply 5 dots (1 mm) of 0.1 micron diamond polishing paste to the glass plate. Apply 12 drops of Isocut fluid to the glass plate.The isocut fluid also protects the glass plate, so make sure that the piston always has isocut fluid where it travels around the plate. Mix the Isocut fluid and the diamond past with your finger making sure that all of the paste is distributed approximately where the sample will be polished. Smear it out over in a circle.
4. Mount the bevel on the lapping/polishing jig, and mount the jig on the arm of the circular track polisher. Pull the piston up, partly out of the cylinder, and position the jig so that the bevel is tangential to the circular motion (i.e. bevel edge in the radial direction). See Fig. 3 for more details.

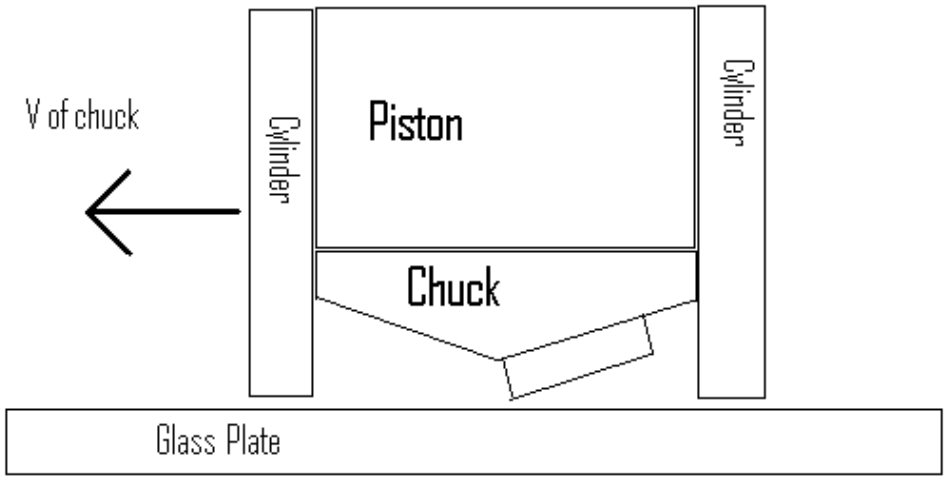

Fig. 3: Polishing direction.

5. Move the arm slowly around (1 revolution/sec). The direction of rotation should be so that the to-be created bevel edge indicated in Fig.2 is NOT leading. Make approximately 100 turns. Make sure that sample does not touch the glass plate at areas that are not covered with the Isocut-diamond paste cocktail. Add isocut fluid as needed. The polishing process may create multiple bevels if the piston is removed from the polisher during the polishing process.
6. Remove the jig from the arm of the circular track polisher. Observe the sample. For small angle BBs, it is possible that the bevel edge is not exactly parallel to the "roof-top" of the BB. This is ok.
7. Wash the sample of with water. Dry the sample, and then clean it with acetone. Use a q-tip to clean the bevel you created. Rotate the q-tip clockwise while pulling it towards you over the bevel (for left-handed persons: rotate it counter-clockwise while pulling it towards you over the bevel).
8. Clean the glass plate of the circular track polisher with water.

Preparing the SSM-130:

1. Switch on the power-strip of the SSM-130. Check the air pressure gauge. On the front of the equipment are two small orange lights (see Fig. 1). These lights are blinking if the electrodes are down. Do not move the XY-stage if those lights are flashing as you might damage the electrodes. (If you have trouble with the lights, try turning the power switch off and quickly back on. On-Off-On quickly.)
2. Before we can start with a measurement, we have to make sure that the electrodes are still conditioned correctly. Although the SSM-130 is equipped with a microscope, it is not possible to observe the electrodes through the microscope. A gauge block can be used to switch the sample between the measuring position (position of the electrodes) and the observation position. Use the 1" side of the block to place the sample in the measuring position, and use the ½" side of the block to place the sample in the observation position. Place the gauge block in the observation position. Place the QTA sample on the XY-stage. Find a smooth spot on the triangular sample so that it is easy to determine the probe separation from the track ("electrode-prints") the electrodes leave in the material.
3. If the electrodes are up (i.e. no flashing orange lights), you can move the sample to the measurement position. If the electrodes are down check the air pressure. Under no condition move the sample to the measurement position if the electrodes are down: It will damage the electrodes.
4. On the far right side of the XY-stage is a gearbox (see Fig. 1). A metal disk with numbers on it. You can switch gear by pulling the knob out and rotating the disk. If you put the disk in between two numbers the instrument will not be in gear. Put the instrument in gear 10. This means that the distance between two steps will be 10 micron. Make sure that the system is in gear by pushing the black button near the front of the instrument a few times. Every time you push it, the micrometer will move 10 micron.
5. Check the connections of the electrodes. Start the computer, the SSM-130 program will automatically start. Select "measure a test sample" and fill out the measurement form. Select 10 data-points and start a measurement. Follow the

directions on the screen. If the resistance of the triangular sample is less than 1200 ohm the electrodes are in good shape. If the resistance of triangular sample is considerable more than 1200 ohms, the electrodes need to be re-conditioned. For detail on how to condition the electrodes see file ProbeConditioning.doc. If the resistance is 1 one ohm or lower, check the electrodes. It normally means that they are touching each other.

6. Measure the electrode separation. If you know the step size, it is possible to make a good approximation of the probe separation by looking at the track spacing. The electrode separation should be approximately 200 micron.
7. Measure the prints the electrodes leave behind. It probes are well conditioned the prints should have a radius of 2-3.5 micron. The best way to estimate the size of the prints is to vary the step size and figure out for which step size the prints will touch each other.

Measuring the sample:

1. Screw the BB with your sample on the sample-chuck.
2. Place the sample chuck on the XY-stage with the beveled side of the sample facing the electrodes.
3. Orient the sample-chuck so that the bevel edge of the sample is perpendicular to the electrodes. Use the crosshairs in the scope. Check the relative position of the probes with respect to the crosshair by using the QTA.
4. Put the system in gear (2.5 or higher) and advance with the manual button until the XY-stage is starting to move.
5. Start your measurement. The data will be saved in an SDA file. The data is saved as a *.sda file in the root directory or the ssm-130 directory. In order to export the data into a format compatible with a spreadsheet like EXCEL the file needs to be converted to a *dif (data interchange format). This can be done by copying this file onto a 3.5" diskette. Take this file to the SULU computer and copy it into the c:\D150data\ folder. Run on SULU the program c:\D150\D2150dis.exe from the DOS prompt. Go to the "File Operations Menu" (4), choose "Permanent File Operations" (2), find the file you want to convert then use the "recall V1.6 option" (F6), go to "Temporary File Operations" (TFO), save file as "<name>.dif and then exit (F2, F1), go back to Windows (Alt-D), Open File. The dif file can be read by Excel.