LEHIGHTON
Electronics, Inc.

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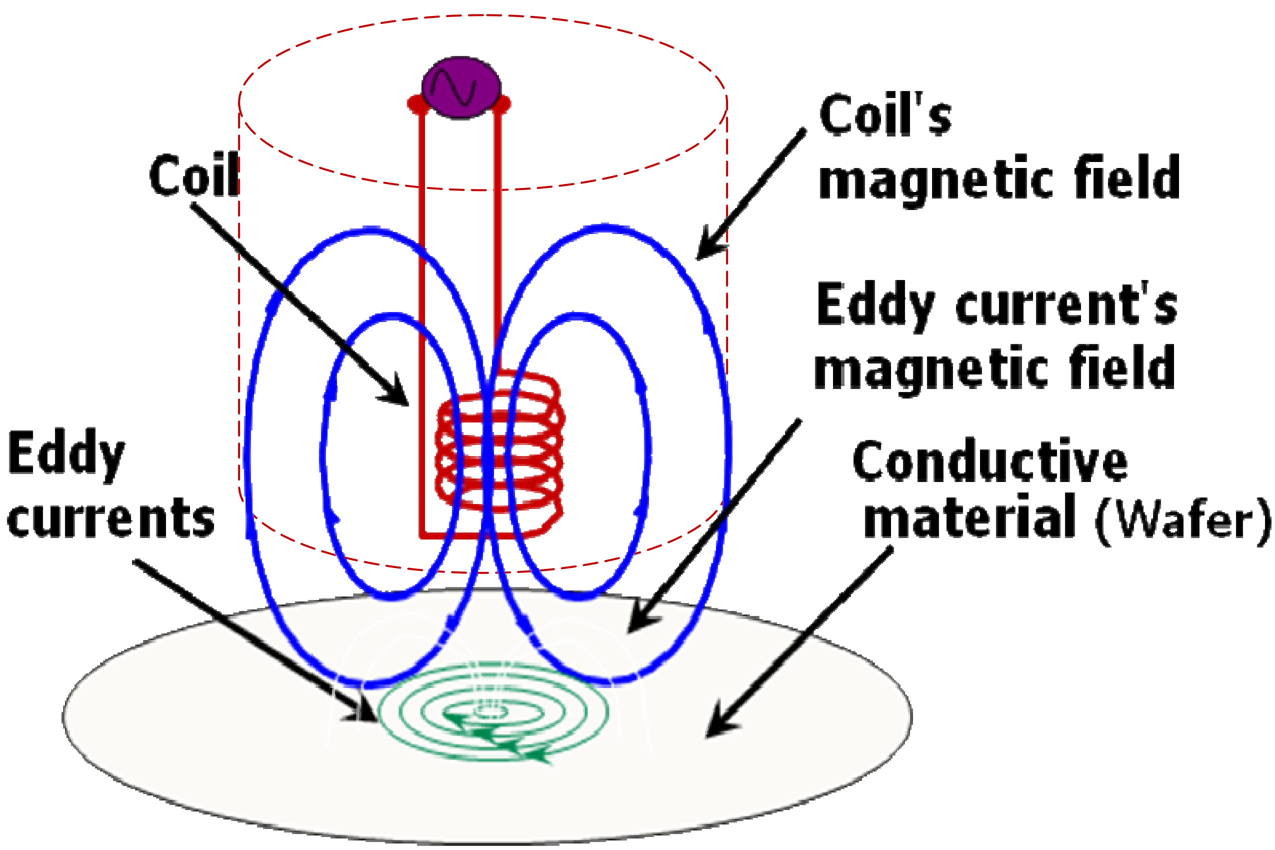
Quality Service Since 1963

1510 THEORY OF OPERATION

Introduction:

The 1510 system measures sheet conductance (mhos/square) as a proportional DC voltage. In the high range the voltage signal is approximately ten times the sheet conductance. Monitoring the 'automatic gain control' (AGC) of an oscillator that drives the sample-sensing coil generates this DC voltage. The sample-sensing coil provides a magnetic field that passes through the sample to a ringing coil-capacitor set. The amount of energy the sample absorbs by creating Eddy-currents causes the oscillator power to change. The AGC compensates for this change in energy, thus producing a DC voltage change. The system measures the DC voltage prior to moving the sample under the coil and after the sample is moved under the coil. The difference is the proportional DC voltage mentioned above that is captured by the computer to calculate the sheet conductance. Since the circuitry can drift with time and cannot be adjusted to absolutely perfectly represent the conductance, the system has to be calibrated.



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Calibration:
The sample has a temperature coefficient associated with it as shown in table 5 of F84 in the ASTM Standards. The calibration procedure tells the computer what the voltage signal has to be to measure the sample at the temperature of the sample. The process of calibration measures the sample voltage and then calculates the factor that when multiplied by the measured voltage corrects for the circuit differences. This factor is stored for all future measurement corrections until the system is re-calibrated. There is another part of the calibration that is important when the high range is used. This is the rail calibration part. The sensitivity of the high range is such that any materials that can affect the magnetic field that move as the sample moves will cause a change in the DC voltage. There are bearings on the wafer support rails that can cause this to happen. Rail calibration measures the voltage change as a function of rail position and stores this in a table. The table is used to calculate the exact voltage for a rail position in a test sequence to subtract from the measured DC voltage of the AGC to get the corrected voltage. This is used in the calibration and measurement of the samples when using the high range of the system. The calibration process takes time since the wafer is placed at the reference position for approximately 8 seconds to temperature stabilize after each measurement at the center of the wafer. This measurement cycle (reference to center) is repeated 5 or 10 times (choice of operator). The average of each cycle measurement is used for the wafer measurement. The calibration cycle should be repeated 3 to 5 times and the calibration factors recorded. The calibration factors should be consistent to insure the system is stable.

Measurement:
The sample measurement process moves the wafer to a reference position and measures the DC voltage. Then the sample is moved under the coil and another DC voltage is measured. The computer subtracts the effects of the rail position from these voltages (high range use) and takes the difference of the resultant voltages. This resultant is then multiplied by the calibration factor to get the sheet conductance. When the system is used to measure an unknown sample, the conductance is calculated for the sample for the temperature of the sample at that instant of time. A single center measurement should be sufficient to get the sheet conductance (1/sheet resistance) of the sample. This is generally used in production. When mapping a sample, the position of the wafer is generally different for each point. Both of these conditions will measure the sample accurately. When the '10center-test' plan is used, there is another effect on the sample. As stated above, the sample absorbs part of the magnetic energy used to test the sample. This energy produces Joule heating. The design of the system considered this effect and selected as low energy as possible to obtain the sheet conductance with minimum Joule heating and still stay above the noise level. Typically the Joule heating when the wafer is subjected to the magnetic field for an extended period of time (to reach equilibrium) results less than 1.5°C within the sample measurement area. The time it takes to reach equilibrium is much longer than the time to measure 10 centers. A simple test will show this effect. Figure 1 shows such a test.
The test conditions are:

Sample: 10Ω-cm 2in standard wafer
Test Range: High
Auto Zero ON

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Auto Ref. OFF
Test Plan: 150 center

Results show the sheet resistance (1/conductance) starts at approximately 162.2Ω/□ and raises asymptotically to a final sheet resistance of approximately 163.5Ω/□. It is obvious that the highest slope (largest) change is at the beginning. The overall standard deviation for the test performed is 0.195%. But if the last 20 (twenty) measurements are used (at equilibrium), the standard deviation drops to 0.035%. The 10 center testing changes happen at the beginning of this test plot. If the testing is performed with the Auto ref ON, the slope and the equilibrium resistance should be slightly less because the power that is dissipated in the sample is not continuous. This is because the sample is moved out of the coil area to re-measure the reference voltage after each center measurement.

Noise Specifications:

The system noise specifications are meant to describe the system noise from the electronics and any mechanical vibrations. There should be no mechanical vibrations at the time of measurement because the motors and robot are in a holding state. The noise specifications are not intended to take into account the physics of the Joule heating that will always be there to some extent. This standard deviation noise figure is presented above and repeated here for completeness as 0.195% for the entire test and 0.035% for the last 20 measurements.

LEI 1510EC
(With Light Shield Option)

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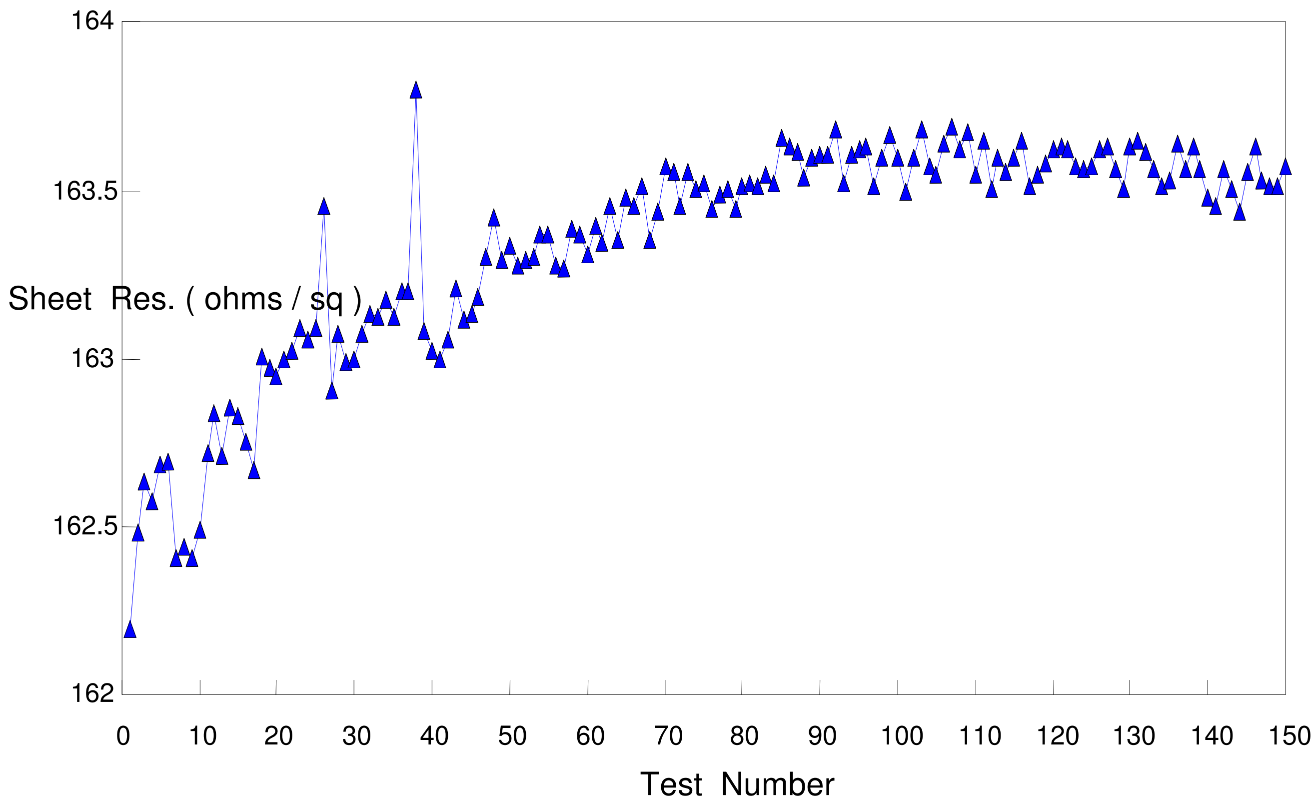
FIGURE 1 'Test To Show Joule Heating'

Tested at LEI with 10ohm-cm Wafer on #195



Test conditions: Auto zero ON, Auto ref. Off, 150 center test plan, test time under cond. head approx 55 sec.

Avg. Resistance = 163.3, % std. dev. = 0.195 %, last 20 meas. avg = 163.55, % std. dev. = 0.035 %