

SEMICONDUCTING WAFERS

Delcom sensors measure the sheet resistance of wafers

Semiconducting wafers require a specific resistivity depending on the application for which the material is being produced.

Delcom sensors can read the sheet resistance of these wafers regardless of the doping/process used to achieved target sheet resistance to include:

- Total bulk n-type or p-type wafer doping during wafer fabrication
- Partial wafer doping via diffusion
- Partial wafer doping via ion implantation
- Doping using alloy
- Deposition processes such as Chemical Vapor Deposition (CVD), Physical Vapor Deposition (PVD), Atomic Layer Deposition (ALD)

Similarly, Delcom sensors can read sheet resistance irrespective of the base material of the wafer to include:

- Silicon (Si)
- Gallium arsenide (GaAs)
- Gallium nitride (GaN)
- Silicon carbide (SiC)
- GaN
- Sapphire
- Glass

It should also be noted that sheet resistance is also affected by thermal and physical activities performed on the wafer such as: polishing, annealing, etching, and oxidation. For this reason, sheet resistance readings should be taken using a Delcom sensor at key steps in the fabrication process.

Figure 1: Example – PV wafer after doping



Why use Delcom to measure the sheet resistance of wafers

It is important to note that because eddy current meters rely on a magnetic field to achieve their reading, they have a number of advantages over four-point probes to include:

- Is non-destructive
- Reads through insulating layers
- Measures moving material
- Provides nearly instantaneous readings
- Provides real-time process inspection

Process-specific employment strategies for Delcom sensors

Eddy current sensors can be used in a straight-forward way to measure the sheet resistance of bulk doped wafers. Simply insert the wafer into the sensor's magnetic field and observe the reading.

Figure 2: Measuring sheet resistance of bulk doped wafer



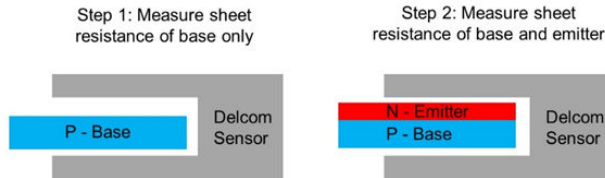
Eddy current sensors, use a magnetic field to inductively couple with the conducting layer of any material being measured. As such, any material placed within the field of an eddy current sensor will be measured even if the material is made of various layers separated by insulating layers. The sheet conductance of the entire stack is the sum of the sheet conductance of each layer – this phenomena is call superposition.

Therefore, in order to ascertain the sheet resistance of a bulk intrinsic doped wafer that was further processed to have a second extrinsic doped layer, the user must first measure the sheet resistance of the bulk doped wafer before the creation of the second doped layer. Then, after the creation of the second doped layer, the wafer is measured again. The sheet conductance of the second doped layer is merely the sheet conductance of the second reading minus the sheet conductance of the first reading. To get to sheet resistance, the sheet conductance need only by inverted. This is called the eddy current two-step process.

Eddy current two-step process:

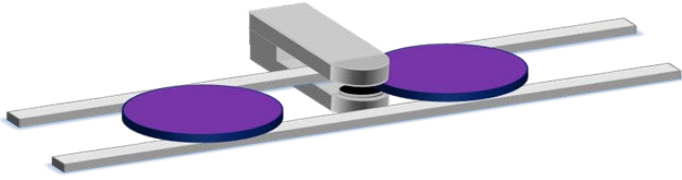
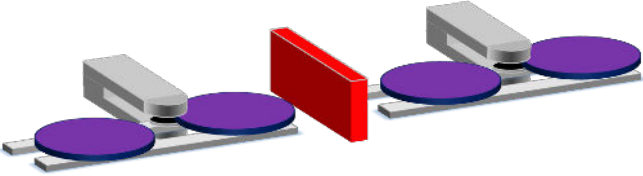
- Step 1: measure the wafer prior to creation of second doped layer
- Step 2 measures the wafer after creation of second doped layer

Figure 3: The two-step eddy current method



Inline sensor deployment strategy for Delcom sensors

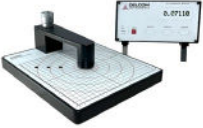
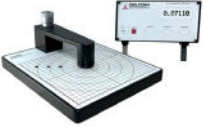
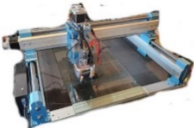


In general, Delcom sensor deployment strategies can include one or more of the following deployment tactics.

Deployment Strategy	Image	Advantages
Single sensor single spot		<ul style="list-style-type: none"> • Most cost-effective option on the market • One single fixed-point • Achieve instantaneous process feedback • Automatically tare between wafers
Two sensors monitoring downstream	<p>Step 1: Measure sheet resistance of base only</p> <p>Step 2: Measure sheet resistance of base and emitter</p> 	<ul style="list-style-type: none"> • Measure sheet resistance of both base and emitter

Recommended sensors

Delcom recommends the following sensors based on the user’s material, stage of development, and application.

Use case	Image	Recommended Sensor	Use case

Benchtop		RD200	<ul style="list-style-type: none"> • For material up to 12 mm thick • For materials up to 200 mm x 200 mm
Benchtop		RD450	<ul style="list-style-type: none"> • For material up to 12 mm thick • For materials up to 450 mm x 450 mm
Benchtop		RM400	<ul style="list-style-type: none"> • Automatic mapping • For material up to 400 mm x 400 mm
Inline		20J3	<ul style="list-style-type: none"> • Most cost-effective inline solution • 200 mm reach and 3 mm gap
Inline		OEM	<ul style="list-style-type: none"> • Variable position, gap, and spot size • Customer decides where and how to mount • Perfect for tool integration

Recommended Delcom sensor range

A specific resistivity is needed depending on the application for which the material is being produced. Measuring the resistivity of a wafer is quite difficult for a number of reasons to include the difficulty of working with a disc-shape, establishing perfect contact, etc. So, wafer researchers and manufactures instead measure sheet resistance. Sheet resistance is a measurement of per unit surface area. It does not present the difficulties of measuring resistivity yet still accomplishes the task – measuring the resistance to current flow and movement of electron and hole carriers in the wafer or layer of a wafer.

Typically for an n or p doped silicon wafer, sheet resistance ranges from .05 ohms/square to 5,000 ohms per square.

Figure 4: typical sheet resistance target values by common applications

Product	Material	Target sheet resistance in ohms/square	Low sheet resistance in ohms/square	High sheet resistance in ohms/square
All	n or p doped wafer		.05	5000
LED	n-type cladding layer in GaN and Sapphire wafer	20		

Crystalline PV solar cell	n-type emitter layer		70	90
Integrated Circuits (ICs)	Boron p-type dopant			
Power devices	Antimony n-type dopant			

Delcom sensors measure sheet resistance. Delcom makes sensors in four ranges – each range able to measure a different range of sheet resistances. When considering which sensor is right for a particular application, the right range of instrument must be selected based on the target sheet resistance of the material.

Figure 5: Delcom’s sensor ranges:

Range Name	Min Sheet Resistance in ohms/square	Max Sheet Resistance in ohms/square
x10	5	100000
x1	0.5	10000
÷10	0.05	1000
÷100	0.005	100

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