OPTOSKY
Spectroscopy Solutions

Datasheet

Capacitive non-contact displacement sensor	SM530

Features

- Double-sided capacitive measurement
- Non-contact, non-destructive testing
- No sample pretreatment required, non-destructive measurement
- The module testing speed is fast, the precision is high, and the repeatability is good
- Thickness measurement range: thickness 100~1500 µm
- Measurement accuracy: <1% or ±5µm
- Result output: UART
- Three-electrode structure and electric field shielding ring construction
- The probe does not exert mechanical force on the measured object
- Low component cost and easy installation
- The conductivity of the measured object does not affect the measurement

Application

- Factory inspection of silicon wafer manufacturers, automatic sorting
- Incoming material inspection and process monitoring of monocrystalline, polycrystalline, sliced, solar cell wafers, etc.
- Metal thin film thickness measurement
- Support materials SiC, GaO, GaN and other silicon wafers

Description

The SM540 thickness measurement sensor uses a large gap between the dielectric constant of the silicon wafer and the air. Silicon wafers of different thicknesses have a significant impact on the capacitance value, so that the change of the thickness can be deduced through the change of the capacitance value. Capacitive thickness measurement, non-contact, non-destructive, fast, allows each silicon wafer to be directly measured in the production process, optimizes the semiconductor production process, reduces cycle time and cost in the production process, improves yield and production efficiency, and optimizes the production process efficiency and effectiveness.

During use, 1-6 pairs of upper and lower probes are used to measure the wafer thickness at different positions to calculate the average thickness of the wafer and the total thickness variation (TTV) thickness deviation to control the yield rate in the silicon wafer production process.

Based on the wafer thickness information, resistivity values can be obtained using eddy current techniques to report the resistivity of the sample under test.

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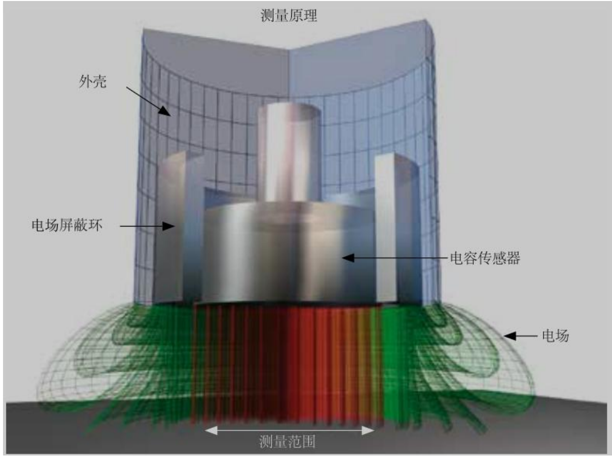
1. Work Principle



Working principle of capacitive non-contact displacement sensor

SM540 is designed and developed based on the principle of ideal plate capacitance, and the measured object and the sensor are each used as a plate electrode. Give the sensor a continuous and stable alternating current, and the amplitude change of the alternating voltage is proportional to the distance between the capacitance and the measured object. After the alternating current is demodulated, an analog signal proportional to the distance can be output. The main function of the SM540 sensor is to analyze the impedance value of the plate capacitor, which is proportional to the distance from the capacitor to the measured object.

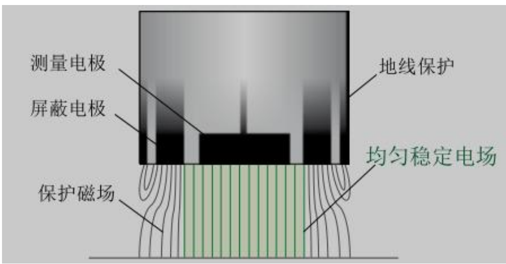
$$Xc = \frac{1}{j\omega c}$$

$$\text{Capacitance:} \quad C = \varepsilon_r \cdot \varepsilon_0 \cdot \frac{\text{areaA}}{\text{aread}}$$

Since during the measurement,j、ω、ε_r、ε_0、areaA does not change, they can be replaced by a constant coefficient. Therefore, the impedance Xc of the capacitive plate is only related to the distance value.

$$X_c = \text{constant} \cdot \text{distance value}, \ \text{constantK} = \frac{1}{j\omega A\varepsilon_0\varepsilon_r}$$

In practice, this theoretical relationship is effectively enforced because the sensor probe is constructed with an electric field shielding ring.



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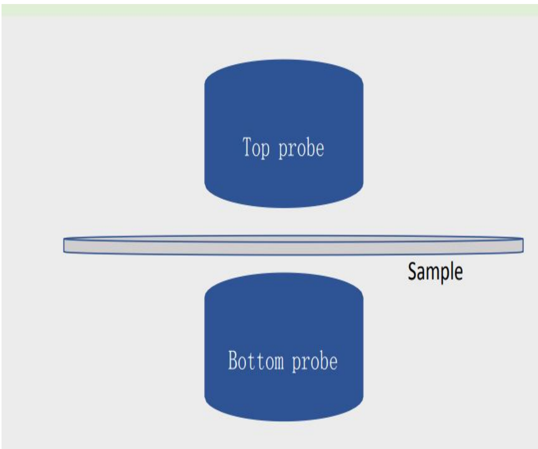
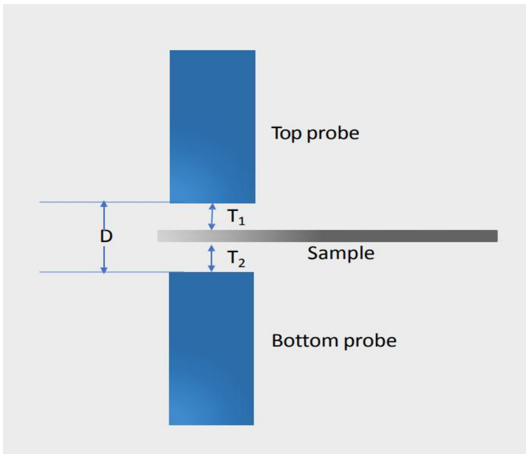
SM540 is different from capacitive sensors of other manufacturers, it innovatively adopts three-electrode probe design. In this design, the electric field shield ring and the ground wire guard are located at the front of the probe, mounted together with the measurement electrodes. This means that the SM540 capacitance probe can be mounted flush in conductive materials. In measuring tasks that require multiple probes, the probes can also touch each other. The three-electrode probe design can effectively avoid interference in the measurement environment.

Capacitive measurement system, equipped with unique active noise reduction cable and active electric field shielding ring capacitance. The exceptional quality of the measurement signal is due to the double-shielded construction. The measurement system has almost perfect electrical protection, which makes high-precision measurement possible. In addition, the electric field shielding ring electrode provides a completely uniform and stable measuring electric field for measuring tasks requiring ultra-high stability, immunity to interference and precision.



(a)



(b)

The basic principle of capacitive thickness measurement is to calculate the capacitance value of the flat capacitor composed of the probe and the silicon chip. For a capacitor composed of two parallel conductor plates with air in the middle, the capacitance is proportional to the area of the plate, and is proportional to the area of the two plates. The distance between them is inversely proportional. When measuring the thickness of the silicon wafer, the silicon wafer and the test electrode form a capacitor: the silicon wafer is a conductor plate, the test electrode is another conductor plate, and the distance from the test electrode to the lower surface of the silicon wafer is fixed. Since silicon is conductive, the thicker the silicon, the smaller the gap between the two plates of the container. (b) wafer thickness: T=D-T1-T2

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2. Parameters

Number	index	parameter
1	Sample size	100~210 mm
2	Structure	single crystal or polycrystalline
3	Measuring range	100 ~ 1500 μm
4	Precision	<1% / ±5μm
5	Repeatability	<0.5%
6	Detection distance	0.5 radians
7	measuring speed	Speed Depends on Wafer Size
8	Probe size	⌀ 26 × 47 mm
9	sample support	online test
10	Result	LCD display supports graphic test

3. Applicable detection object

In order to ensure the linearity of the signal output within the full range, the measured object must meet certain requirements. The impedance value of an ideal plate capacitor can be equivalent to a circuit composed of a capacitor and a resistor connected in parallel with it.

The SM540 capacitive displacement sensor can detect the displacement of the following materials:

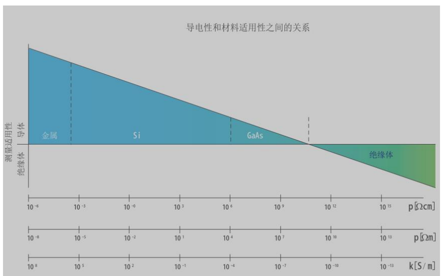
Metal material: When measuring metal objects, the influence of the resistance part can be ignored, and the impedance value is only determined by the capacitance part.

Insulating material: Only the resistive part affects the impedance value of the plate capacitor.

Semiconducting Materials: Most semiconducting materials can be measured in the same way as conducting materials. The requirement is that the capacitive part of the impedance value be significantly larger (>10x) than the resistive part. This requirement is generally true for the semiconductor industry.

Not only that, under certain circumstances, semiconductor materials with poor conductivity (such as GaAs) can also be measured as conductors.

However, some debugging has to be done. Examples include reducing the operating frequency or temporarily and partially increasing the conductivity.



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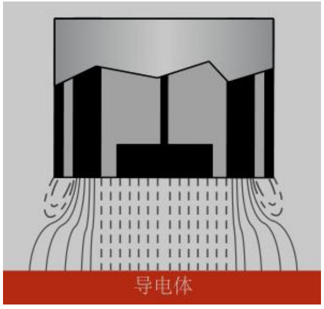
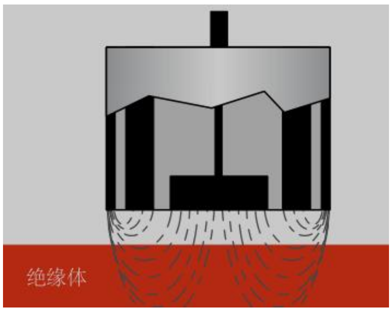
3.1. Detection of conductive materials

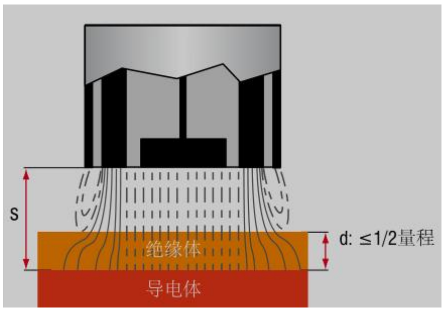


All conductive or semiconducting materials can be perfectly measured. The conductivity of the measured object will not affect the linearity and sensitivity of the measurement

3.2. Inspection of insulating materials



The flux lines travel through the insulator back to the probe housing. The induced capacitive reactance X c depends on the distance between the probe and the insulator. SM540 can detect insulators, but the corresponding resolution and accuracy will be reduced. Parameter calibration/compensation is highly recommended.



In order to better detect the thickness of the insulating material, SM540 can also add conductive material at the bottom of the insulating object to measure the thickness of the insulating material, which can effectively improve the measurement accuracy of the insulating material. At this time, the lines of magnetic force pass through the insulator and reach the base layer of the conductor. If the thickness of the insulator varies, it will affect the probe's induced capacitive reactance Xc. Therefore the distance from the

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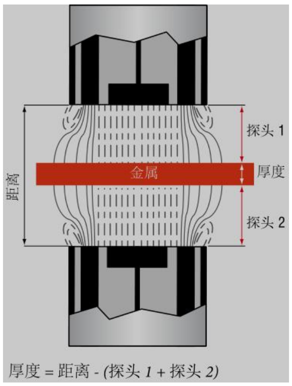
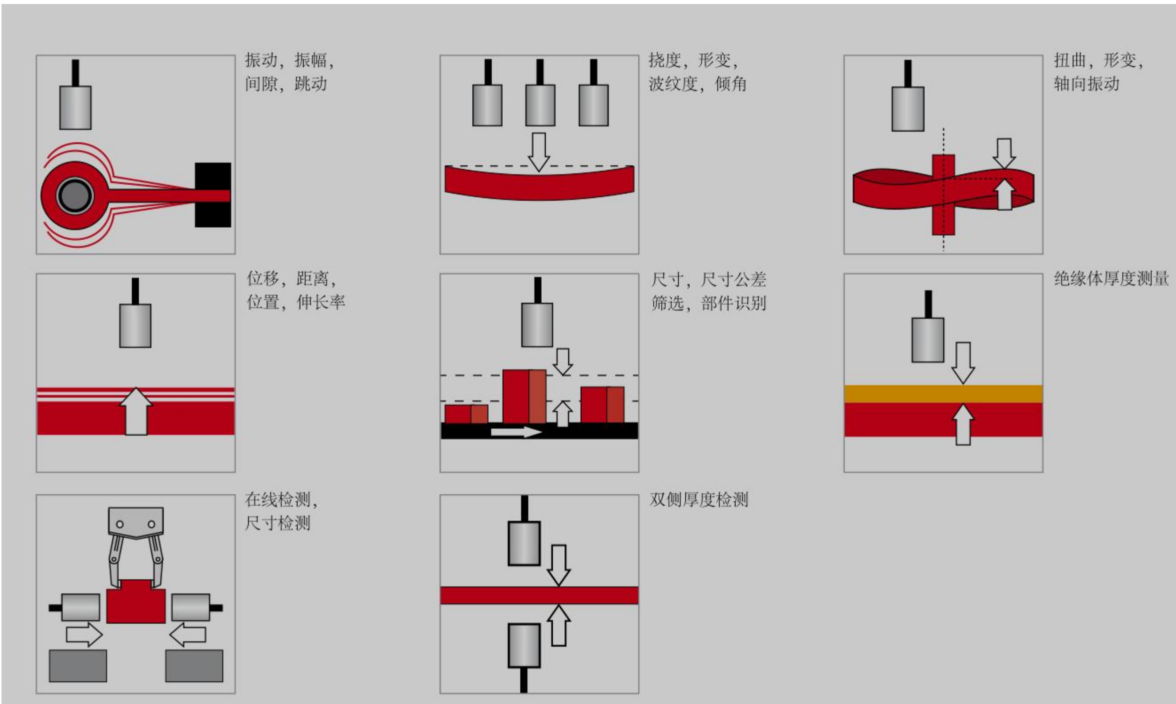
probe to the conductor must be constant.

3.3. Thickness measurement of metal objects under test



Two opposing capacitance probes can be used to measure the thickness of metal from both ends. Using this method, thickness measurement can be achieved even if the thickness of the metal strip under test is on the order of microns. Each probe generates a linear measurement signal according to the distance from the probe to the surface of the measured object. If the distance between the two probes is known accurately, the thickness value of the measured object can be obtained. Derived from the principle of capacitive measurement, this measurement requires that the magnetic lines of force cannot penetrate into the measured object. If the measurement points are synchronized, measurement can be performed without grounding the object to be measured.

4.Application



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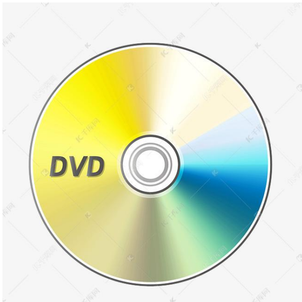
4.1. Optical disk nickel layer thickness measurement

We use CDs, DVDs, HD-DVDs and Blu-ray Discs to store data a lot in our daily life. The surface of the substrate (silicon or glass) of these discs needs to be coated with a thin layer of nickel. The absolute thickness of the nickel layer needs to be measured to control the plating process. The capacitive displacement sensor provided by Miiridium Company of Germany is used to measure the thickness and outer contour of the nickel layer. The two probes are respectively located at the upper and lower ends of the disc under test, and the measurement result can be obtained by moving the disc under test. Subtract the measurement results of two capacitive displacement sensors to obtain a very accurate thickness value.



4.2. Wafer and Semiconductor Industry Measurements

Thickness is the main control parameter in the production of photovoltaic silicon wafers. By filtering wafers with non-standard thickness and shape, the waste caused by silicon wafer breakage can be effectively reduced.

In the semiconductor industry, in order to achieve process requirements and production efficiency, it is necessary to meet ultra-high precision measurement. SM540 is used in applications such as on-line detection of the thickness of solar photovoltaic silicon wafers.

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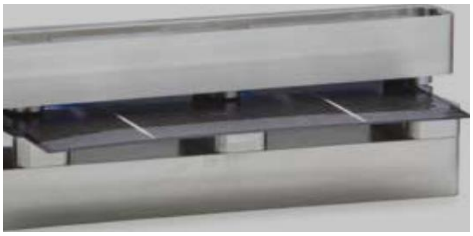

Three-point measurement of wafer thickness

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