Droplet Lab

The Practical Guide to Surface Science for the Electrical - Electronics Industry

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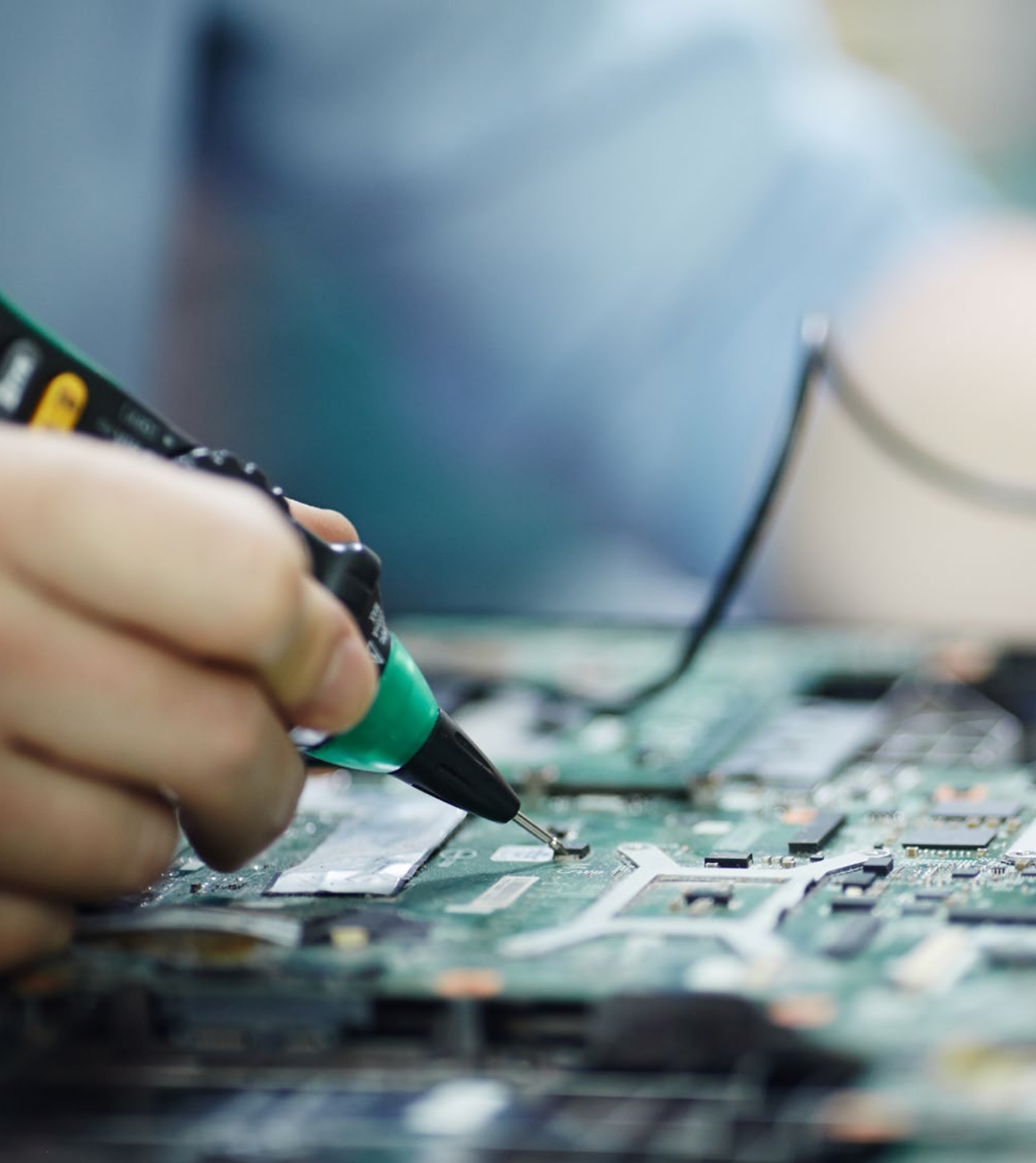

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INTRODUCTION

Surface property measurement of various electronic and electrical system are essential for quality control and reliability. As an example, a good adhesive and wetting behavior of circuit is paramount to prevent the possibility of circuit failure. In electronic and electrical components, the adhesive and wetting behavior is affected by various factors that includes presence of contaminants on the boundary. [1] Other areas are:

Soldering

Cleanliness

Electronic

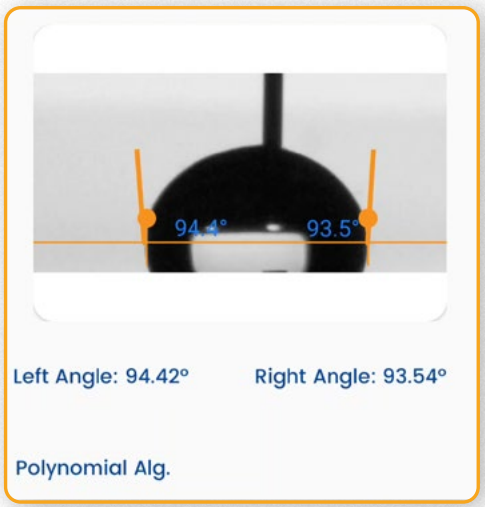
Chip Cooling

Printed Electronics

Contact Angle Measurement

Contact angle quantifies the wettability of a surface, representing the angle between the surface of a liquid and a solid surface. A high contact angle on a semiconductor surface results into poor adhesion to other materials, causing problems such as cracking and delamination. By measuring the contact angle, manufacturers can ensure the good adhesion of semiconductors to other materials [2].

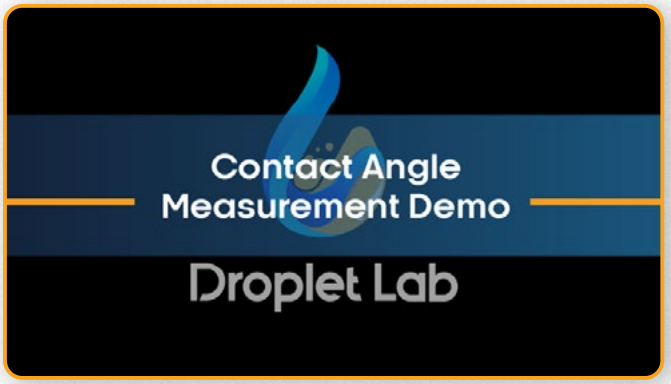
A low contact angle can indicate surface cleanliness Such measurement can be used for QC applications. Finally, for printed electronics contact angle measurements can help with conductive ink formulation.



Sample Image taken from Droplet Lab Tensiometer

Droplet Lab offers both Young-laplace and Polynomial methods in our Tensiometer.

Young - Laplace Method	Polynomial Method
Uses the whole drop profile to calculate the contact angle value	Uses only a certain percentage of the drop profile to calculate the contact angle value.
Only compatible with an axisymmetric drop. This is not always seen in practice, as a needle is typically inserted into the drop to increase/decrease the drop volume.	Compatible with both axisymmetric and non-axisymmetric drops.
Measurement results are more consistent compared to the polynomial fitting method.	Measurement results are less consistent, as they are affected by local surface imperfections.



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Learn how Contact Angle measurement is done on our Tensiometer

Dynamic Contact Angle

Ideally, when a drop is placed on a solid surface, a unique angle exists between the liquid and the solid surface. The value of this ideal contact angle (the so-called Young's contact angle) can be calculated using Young's equation.

In practice, due to the surface geometry, roughness, heterogeneity, contamination, and deformation, the value of the contact angle on a surface is not necessarily a unique value but falls in a range. The upper and lower limits of this range are called the advancing contact angle and the receding contact angle, respectively.

The value of Advancing and receding for a solid surface is also very sensitive and can be affected by many parameters, e.g., temperature, humidity, homogeneity, and minute contamination of the surface and liquid. For example, the advancing and receding contact angles of a surface at different locations can be different.

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Learn how Dynamic Contact Angle measurement is done on our Tensiometer

Dynamic Contact Angle versus Static Contact Angle

Practical surfaces and coatings naturally show contact angle hysteresis, indicating a range of equilibrium values. Measuring static contact angles provides a single value within this range. Solely relying on static measurements poses problems, like poor repeatability and incomplete surface assessment regarding adhesion, cleanliness, roughness, and homogeneity.

Practical applications require understanding a surface's liquid spreading ease (advancing angle) and removal ease (receding angle), such as in painting and cleaning. Measuring advancing and receding angles offers a holistic view of liquid-solid interaction, unlike static measurements, which yield an arbitrary value within the range.

This insight is crucial for real-world surfaces with variations, roughness, and dynamics, aiding industries like electrical-electronics, materials science, and biotechnology in designing effective surfaces and optimizing processes.

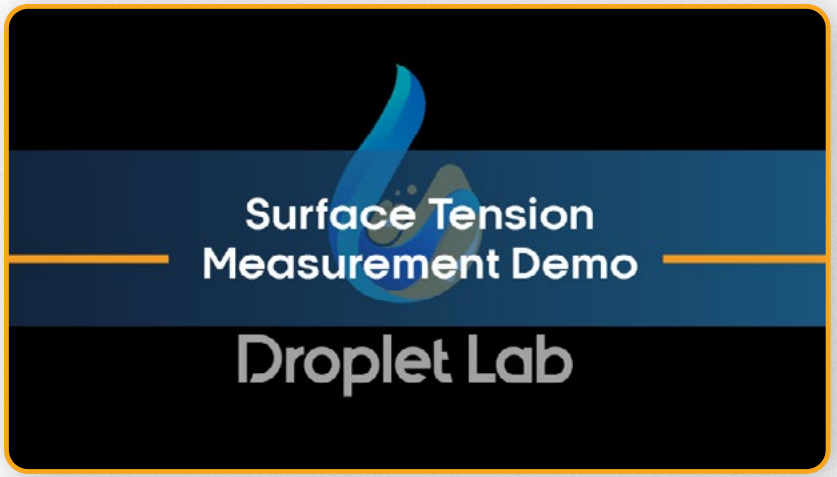
To improve the data quality of your contact angle measurements we recommend you read up on the best practices in the below referenced paper.

Guidelines to measurements of reproducible contact angles using a sessile-drop technique

Surface Tension Measurement

This property measures the force acting on the surface of a liquid, aiming to minimize its surface area. In the electrical industry, to keep the surface insulator and conducting materials contamination free, surface tension measurements are important. As an example, low surface tension of insulator surface makes sure that it will not be contaminated by dust. Surface tension is a critical parameter for a conductive ink used in electronic printing, as it will determine the degree of spreading on a substrate.

Sample Image taken from Droplet Lab Tensiometer



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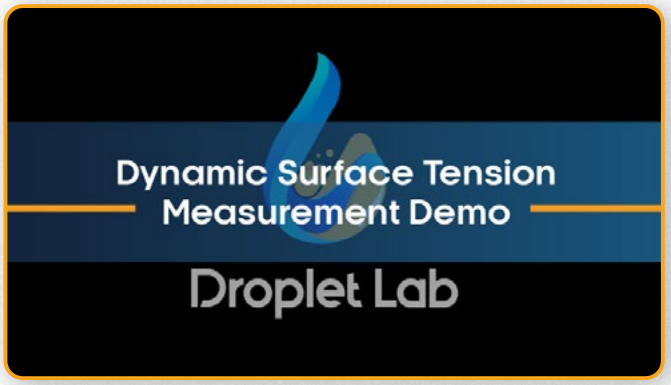
Learn How Surface Tension measurement is done on our Tensiometer

Dynamic Surface Tension

Dynamic surface tension is different from static surface tension, which refers to the surface energy per unit area (or force acting per unit length along the edge of a liquid surface).

Static surface tension characterizes the equilibrium state of the liquid interface, while dynamic surface tension takes into account the kinetics of changes at the interface. These changes could be the presence of surfactants, additives, or temperature, pressure, and/or compositional changes at the interface.



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Learn how dynamic surface tension measurement is done on our Tensiometer

When to use Dynamic Surface Tension Measurement

Dynamic surface tension is particularly important when dealing with processes that involve rapid changes at the liquid-gas or liquid-liquid interface, such as droplet and bubble formation or coalescence (change of surface area), behavior of foams, and drying of paints (change of composition, e.g. evaporation of solvent). It is measured by analyzing the shape of a hanging droplet over time.

Dynamic surface tension has applications in various industries, including Electrical & Electronics, coating, pharmaceuticals, cosmetics, food and beverage, and industrial processes where understanding and controlling the behavior of liquid interfaces is essential for product quality and process efficiency.

Scientific Validation of our Instrument:

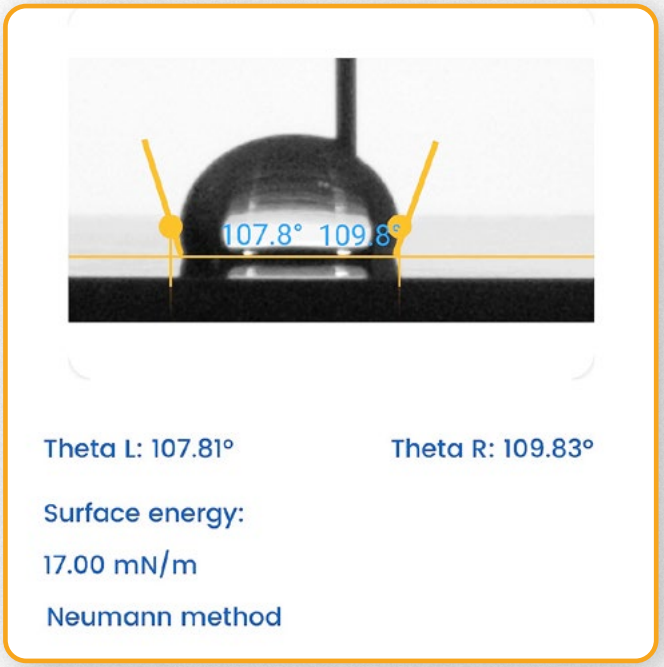
Accuracy and reliability are the cornerstones of any scientific instrument, and concerns regarding the precision of our setup are both understood and acknowledged. While our state-of-the-art tech lays the foundation, it's our unwavering commitment to validation that sets us apart.

This promise of transparency and scientific rigor is supported by two peer-reviewed papers that thoroughly detail and validate the performance of our instrument:

1. Review of Scientific Instruments
2. Colloids & Surfaces A

Surface Energy Measurement

Surface energy refers to the energy required to create a unit area of a new surface. It is a measure of the cohesiveness of the material. Surface energy measurements are crucial to make sure that the material will not be damaged due to moisture. As an example, manufacturer will use high surface energy in semiconductors to prevent it from debonding.



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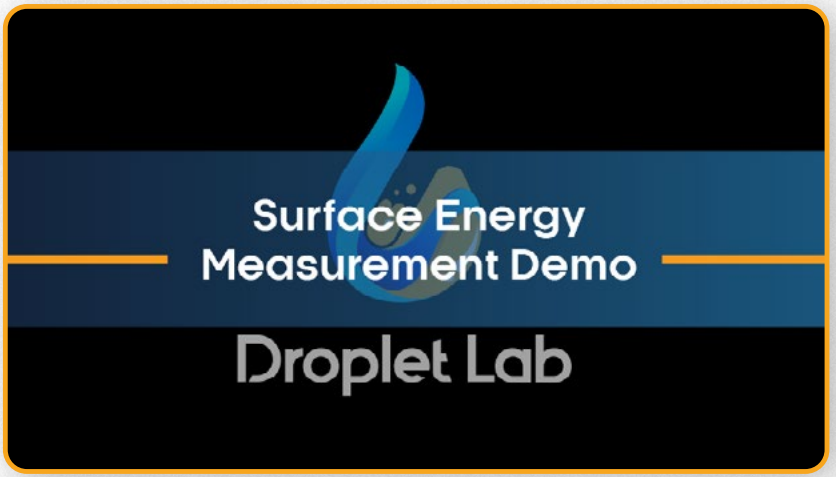

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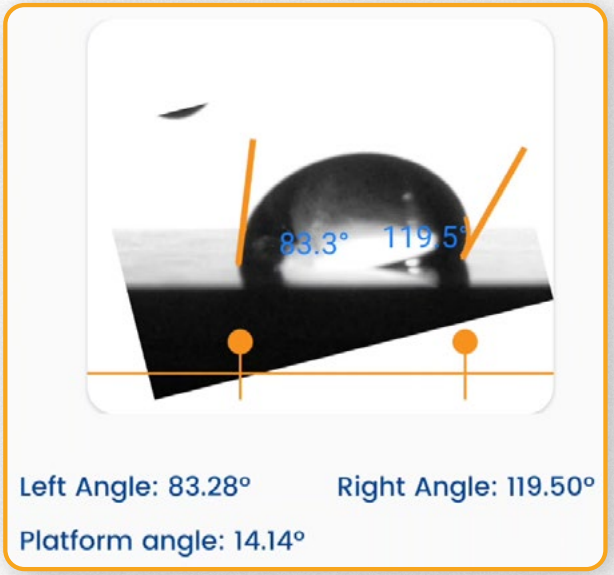
Sliding Angle Measurement

The sliding angle measures the angle at which a liquid film slides over a solid surface. It is commonly employed to assess the slip resistance of a surface. In the electrical industry, arcing and overheating can be caused if two materials are stick to each other. As an example, by maintaining the high sliding angle on an insulator, manufacturers can prevent insulator from these unwanted issues. A high sliding angle for such systems is also an indicator for icing susceptibility. This will lead to icing in high tension live applications.



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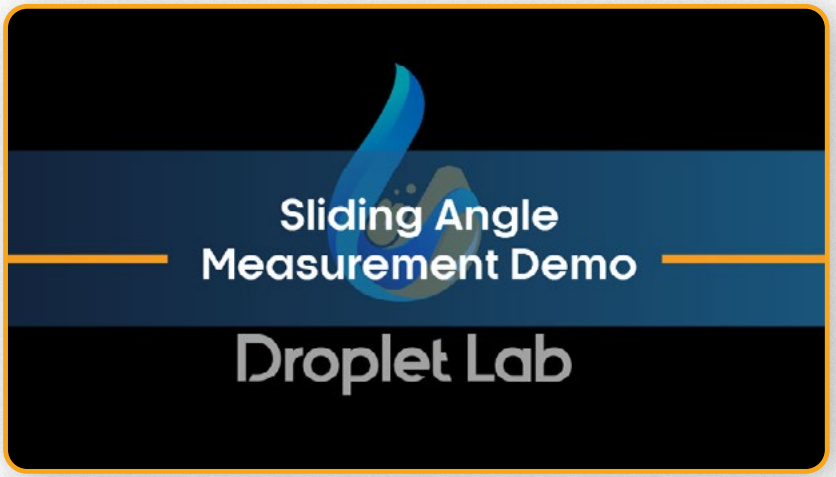

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[Learn How Sliding Angle Measurement is done on our Tensiometer]

By carefully considering and measuring these surface properties, manufacturers can continually improve their products' quality and meet the evolving needs of their customers.

Real-World Implications
Case Studies

Within the electrical electronics industry, several case studies exemplify the advantages derived from conducting surface property measurements.

Presented below are a few illustrative instances:

1 Printed circuit boards (PCBs): Adhesion of the solder mask

Scenario: A manufacturer of printed circuit boards (PCBs) effectively employed in-field data collection to identify an issue with the adhesion of the solder mask to the PCBs.

Application: Through this data-driven approach, manufacturers can pinpoint the problem and implement a solution that significantly improves the solder mask adhesion, reducing PCB defects.

2 Solar Cell: Wettability

Scenario: In the case of a solar cell manufacturer, measuring the wettability of a new type of coating proved problematic. The coating displayed strong hydrophobic properties, making it difficult for the liquid used in the measurement to wet the surface.

Application: A specialized minimal liquid technique was employed to overcome this challenge. By capturing data directly from the manufacturing environment, businesses gain access to precise and timely information, allowing them to detect and resolve issues swiftly, ultimately leading to better product outcomes and decision-making.

2 Managing Liquid Metal Shape for Stretchable Electronics

Scenario: Liquid metals (LMs) are conducting like other metals, at the same time, they also possess the stretchable behaviour of liquid at room temperature. This property makes them suitable for stretchable electronics.

Application: A Electronics manufacturer faces the big problem of attaining the desired shape as due to high surface tension LM's tend to form spherical shape. To deal with this issue the manufacturer decided to breakup the material into smaller chunks. They then decided to stabilise the smaller chunks using a suitable surfactant. This helped them to achieve the desired values of surface tension and hence the desired shape of the LMs.

Given the small size of our instrument and ability to be deployed in the field Droplet Lab can be a partner for in-field solutions.

By capturing data directly from the manufacturing environment, businesses gain access to precise and timely information, allowing them to swiftly detect and resolve issues, ultimately leading to better product outcomes and decision-making.

We are your partners all the way in solving your Business & Technological challenges

If you are interested in implementing these or any other applications you can send an email to us at abhandankar@dropletlab.com

We would also be interested to hear from you if you face any sample related difficulties. Book a call with our engineer to discuss the same with the below link https://calendly.com/gsaini-ob4

Standards and Guidelines

In relation to surface property measurement in the electronic and electrical industry, some of the most important international standards include:

- **ASTM D7334-08 (2022):**

  This standard provides the standard practice for surface wettability of coatings, substrates and pigments by advancing contact angle measurement. As per this standard, hydrophilic and hydrophobic surfaces are defined for the contact angle <450 and >900 respectively. A surface between hydrophilic and hydrophobic comes under the angle between 450 and 900. Water can be used as a test liquid for contact angle measurement [3].

- **ISO 19403:**

  This series provides the description of optical test methods to measure the contact angle, to determine the free surface energy of a solid surface and surface tension of liquids. These description are applicable to the characterization of substrates, coatings and coating materials [4].

Sources

[1] Thomas Skrivanek, Application report: AR234e, KRÜSS GmbH, pp1-4. www.kruss.de.

[2] Study on the Surface Energy of Graphene by Contact Angle Measurements“,” Langmuir, Volume 30, July 2014, 8598–8606. DOI: https://doi.org/10.1021/la5018328.

[3] https://www.astm.org/d7334-08r22.html.

[4] https://www.iso.org/standard/64808.html.