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Study of Contact Angle and Surface Energy of CuS Thin Film

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Abstract – T*his paper we used drop – Shape Analysis technique to measure Contact Angle and Surface Energy of CuS Thin Film. The various industrial applications and Practical importance of goniometer are described. Study of hydrophilic surface of material and wetting behavior.*

Key Words: Contact angle, Surface Energy, Goniometer, Hydrophilic surface (CuS thin film; SILAR method; XRD)

1. INTRODUCTION

The contact angle has received tremendous interest from both fundamental and applied points of view. It plays an important role in many industrial processes, such as oil recovery, lubrication, liquid coating, printing, and spray quenching. In recent years, there has been an increasing interest in the study of super hydrophobic surfaces, due to their potential applications in, for example, self-cleaning, nano fluidics, and electro wetting. Wettability studies usually involve the measurement of contact angles as the primary data, which indicates the degree of wetting when a solid and liquid interact. Small contact angles (90°) correspond to high wettability, while large contact angles (90°) correspond to low wettability. Here we used drop – Shape Analysis technique to measure contact angle and surface energy of CuS thin film. Study hydrophilic surface most natural materials are hydrophilic. The contact angle is always less than 90 degree for hydrophilic surface.

1.1 Definitions:

Angle of Contact:-

The angle between the tangent planes at the solid surface and the liquid surface at the point of contact is called contact angle.

Surface Free Energy:

The energy associated with the intermolecular forces at the interface between two media is called surface free energy.

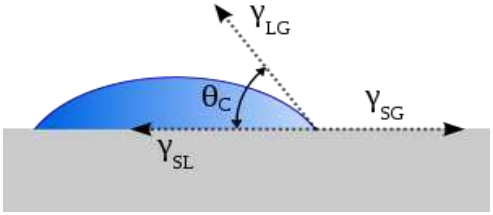

FIG: 1.1 Contact Angle

Surface Tension:-

The force per unit length acting at right angle to an imaginary line drawn in the free surface of liquid is called as surface tension.

Wettability:-

The ability of a solid surface to reduce the surface tension of a liquid in contact with it such that it spreads over the surface and wets it.

1.2 Physical properties of Material

1. **Hydrophobic Surface :**

- Hydrophobicity comes also from the Greek word Hydro (water) and Phobicity (fear).
- Contact angle greater than 90°.
- Examples: Waxes, Oils, Fats, etc.

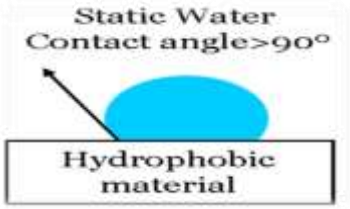

FIG: 1.2 (a) Hydrophobic Surface

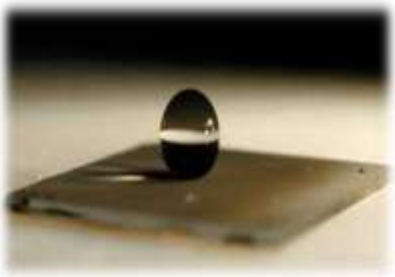

FIG: 1.2 (b)

2. **Hydrophilic Surface :**

- Hydrophilicity, also comes from the Greek word Hydro (water) and Philicity (friendship).
- Contact angle less than 90°.

- Almost all natural materials are hydrophilic in nature.

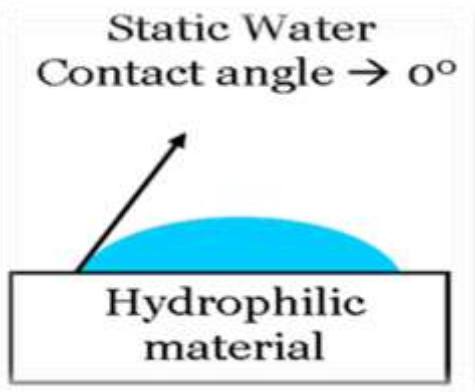

FIG: 1.2 (c) Hydrophilic Surface

FIG: 1.2 (d)

2.1 Industrial Importance of Hydrophilic Surfaces

Hydrophilic coatings exhibit water-loving characteristics. Chemically, this means they participate in dynamic hydrogen bonding with surrounding water. Physically, these chemical interactions with water give rise to hydrogel materials that may exhibit extremely low coefficients of friction. Taken together, such chemical and physical characteristics describe a class of materials that are wettable, lubricious, and suitable for tailored biological interactions.

Usually it is very difficult to remove oil from resins with water unless using detergent. While, utilizing the super-hydrophilic coating, oil can be easily removed from the surface because the surface has so much stronger affinity with water than oil. Therefore, the oil on the super hydrophilic surface is easily removed by soaking the material in water. The importance of contact angle measurement in the textile and fiber industry need not be overstressed. Cotton yarn is usually wetted by water, but synthetic fabrics have definite contact angle for water. Nylon, for example, gives a contact angle of about 400. Fabrics must be coated, therefore, with suitable wetting agents. Otherwise, it will be difficult to remove dirt and soil while washing the fabric with water. The efficiency of insecticide sprays also depends on their wetting behavior on the surface of insects. Usually with most insecticides, an organic liquid having a low surface tension is used as a spray so that it spreads completely. Contact angle is therefore an essential parameter to be considered in any pesticide or insecticide spray formulation.

2. Applications of Contact Angle:

Some of the applications and industries that benefit from a better understanding of contact angle, surface energy, and surface tension.

2.1. Nanotechnology:

Material scientists are interested in designing nano surfaces with unique and controllable properties. In effort to mimic the Lotus leaf, super hydrophobic surfaces are being produced with very low wetting in order to produce high contact angle and provide a self-cleaning attribute. Lotusan paint is an example of a commercial product which mimics the Lotus leaf.

2.2. Semiconductors:

Contact angle plays a critical role in determining wafer cleanliness and assessing the efficacy of HMDS, plasma cleaning, and other cleaning, coating, etching, and bonding processes used in the production of semiconductor wafers. The ramé- hart Model 400 was designed specifically for the semiconductor industry.

2.3. Textile & Fiber

The importance of contact angle measurement in the textile and fiber industry need not be overstressed. Cotton yarn is usually wetted by water, but synthetic fabrics have definite contact angle for water. Nylon, for example, gives a contact angle of about 40 degrees. Waterproofing or water-repellency is an important industrial process, which depends on contact angle values.

2.4. Polymers and Plastics

Most of the polymers like polyethylene, polypropylene, Teflon, etc. shows high contact angle behavior with many liquids. A number of applications of polymers have taken advantage of this situation. An example is the Teflon coated frying pan.

2.5. Detergents

Another area where contact angle plays an important role is in detergency, the process of cleaning clothes, etc., by a surface-active agent. Contact angle measurements of lotions, oils, soaps and other toilet preparations on human skin and hair strands provide valuable information for their correct formulation and are now routine.

3. Experimental and Instrument

Contact angle goniometer ramé-hart Model 500-F1 is Advanced Goniometer with DROP image Advanced. It is

goniometer with 21" rail system, fire wire camera, advanced 3-axis stage with fine and coarse vertical adjustment, micro syring fixture assembly, needle, storage cover, fiber optics illuminator. Support automated dispensing system.

3.1 Materials/Instrument Requirements:

- Sample surface should be at least 0.5 x 0.5 cm in size.
- Liquids used with the plastic pipette tips need to be compatible with the plastic.
- If you don't know whether your material will work, contact NBTC staff before you use the solvent.
- The plastic 20µL micropipette tips can be used for contact angle measurements, not hanging drop measurements. The blunt metal syringe tips can be used for either contact angle or hanging drop measurements.

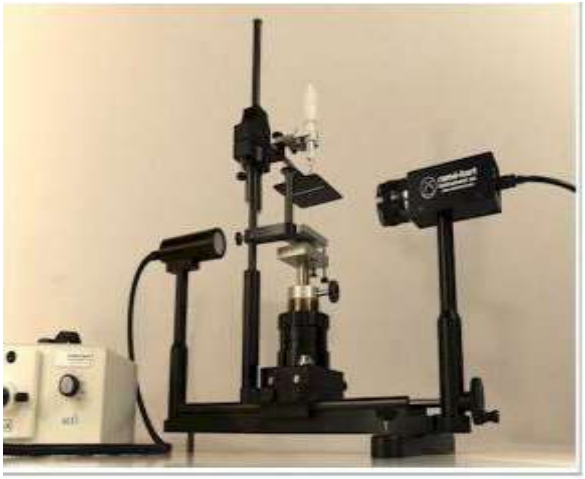

Fig. 3.1"Ramé-hart," – 500 Advanced Goniometer Set Up

4. Preparation of Thin Film:

The copper sulphide (Cu X S) thin films were deposited using relatively simple and new successive ionic layer adsorption and reaction (SILAR) method using copper sulphide and thiourea solutions as cationic and anionic precursors, respectively. The films were deposited on glass and Si (111) wafer substrates. To obtain good quality Cu X S thin film, preparative conditions such as concentration pH and temperature of cationic and anionic precursor solutions adsorption, reaction and rinsing time durations etc. Were optimized. The characterization of the films was carried out by X – ray diffraction scanning electron microscopy, optical absorption, electrical resistivity and thermoemf techniques.

5. Contact Angle Measurement of CuS Thin Film

FIG. 5.1 Hydrophilic nature of CuS thin film as a function of time

Fig. 5.1 shows the contact angle images of the CuS thin films measured as a function of time passes. The decreasing trend corresponds to the absorption tendency of the material. From the measurement of contact angle, the Drop Image Advanced Software provides the direct calculation of surface free energy. Table below shows the calculated angle and surface free energy of CuS thin film deposited by SILAR method.

TABLE 5.2 Calculated values of Contact Angle and Surface Energy of CuS thin film by using Contact Angle Meter

Sr. No.	Time (min)	Contact Angle (degree)	Surface Free Energy (mJ/m^2)
1	1	71.8	40.60
2	5	71.1	41.89
3	10	66.6	43.81
4	15	64.9	44.85
5	20	62.4	46.38
6	25	60.2	47.72
7	30	58.5	48.74
8	35	56.4	50.00
9	40	53.0	52.01
10	45	49.8	53.88

Table 5.2 shows that the decreasing trend of contact angle proves the materials ability to hold the water drop on the surface of the material. The graph plotted by using this data (Fig. 5.3) shows that the relation between the contact angle and surface energy. As time passes contact angle going to decreases and correspondingly surface energy of the material enhances. It means that materials become more wetable, which has the absorption coefficient high. The straight line fitting of this data give the absorption coefficient up to 0.46 indicate that the material has improved absorption coefficient with the function of time. The durability of the material also being enhanced according to the time passes.

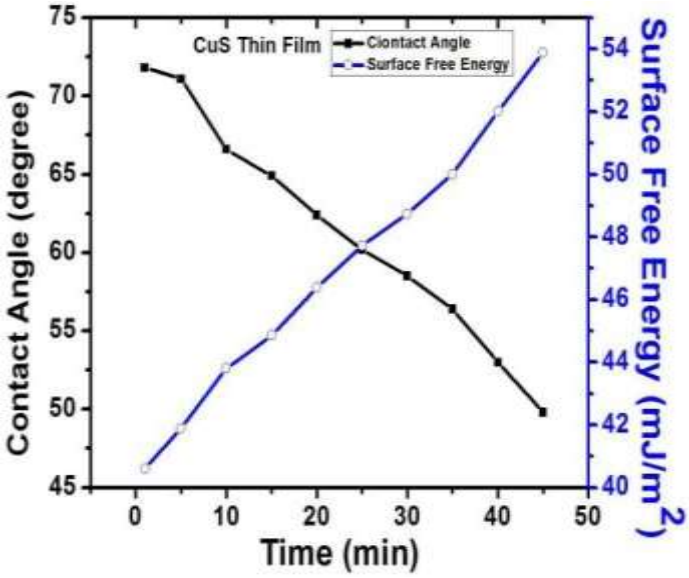

FIG. 5.3 Contact Angle and Surface Energy relation with time

From this data it is easily remarkable that the lower angle material exhibit the good wettability property and found to application in the charge storage mechanism where it high absorption coefficient is required.

6. CONCLUSIONS

Through this paper we have discussed about surface and surface phenomenon such as surface energy, surface tension, angle of contact, wettability. General introduction of instrument and practical importance for industrial applications is mentioned. Measurement of contact angle, surface energy and work of adhesion. Also the measurement is done for hydrophilic thin films in addition to its time dependent wetting behavior.

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