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# Wetting Property of Tin Nanoparticles Thin Films

O. S. Mahdi[1], Nadheer J. Mohammed[1*]

[1] Al-Muthanna University, Al-Muthanna, IRAQ
[2] Department of Physics, College of Science, Mustansiriyah University, Baghdad, IRAQ.

*Correspondent contact: nadheerphys@uomustansiriyah.edu.iq

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## ABSTRACT

Thin film was formed by the method of thermal evaporation of tin. To studying the obtained thin film, we used a field emission scanning electron microscope. The resulting image is processed using the Gwyddion 2.20 program, which is used to determine the values of the contact angles of wetting with a tin of the substrate surface and the diameter of the drops. Droplet experiments were carried out to describe the wettability behavior of the textured surfaces used in this research. The clusters can take various forms, for example, a sphere or a hemisphere. We saw that the adhesion is good when the temperature is 250 ºC for a substrate. In addition, an important parameter at the stage of clusters is their size distribution, since it significantly affects the morphology of the film grown at the second stage.

**KEYWORDS**: Thin Films; Nanoparticles; Wetting property

## INTRODUCTION

Wetting of a substance has been widely investigated since it has many applications in many different fields; from the semiconductor industry to biological applications, to coatings, and many other fields. Wetting by definition is how much a liquid attracts a solid surface. Good wetting is necessary for high-quality coloring, impregnation, and application of paint and varnish coatings, when gluing materials, as well as when soldering and welding metals. Wetting is measured by the contact angle between a solid and a liquid. The contact angle value affects the droplet shape. [1-6].

Adhesive bonding is a key joining technology in many industrial sectors. One of the key bond formation processes is the wetting of the substrates by the adhesive.

The main technological factors affecting the adhesion quality of films are processing of substrates before deposition, film deposition rate and thickness, residual gas atmosphere in a vacuum chamber during deposition [7].

Also, it is known that different surface chemistries can affect the contact angle between a surface and $SnO_2$ [7]. In this paper, we will focus on the droplets of configuration for $SnO_2$ thin film gas sensors, that is, a film whose formation during the deposition of the material on the substrate was completed at the stage of percolation of a droplet that grows to form NPs thin film.

## EXPERIMENTAL

Thin film was formed by the method of thermal evaporation of tin, implemented in a vacuum chamber of an ORION-40T installation (VacTec, Republic of Korea). The deposition was carried out in a vacuum of $10^{-7}$ bar. The oxygen stoichiometry can be controlled by the oxygen pressure in the chamber.

The deposition of metallic Sn onto substrate heated above the melting temperature of Sn ($T_s$=250 ºC > $T_m$=232 ºC) for 30 minutes. In this situation, the evaporated Sn tends to cluster into small spherical droplets.

To studying the obtained thin film, we used a field emission scanning electron microscope MIRA 2 LMU, manufactured by Tescan.

The resulting image is processed using the Gwyddion 2.20 program. Using this program, we determine the values of the contact angles of wetting with a tin of the substrate surface and the diameter of the drops.

First, you need to adjust the desired scale of the resulting micrograph. To do this, we will use the



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distance measurement tool and measure the length of the ruler shown in the micrograph. To obtain a scale, we determine the ratio between the result of the measured length of the ruler and the final length of the ruler, which is indicated on the micrograph.
After setting the scale, measure the contact angles and the diameter of a few drops using the distance measurement tool.

# RESULTS AND DISCUSSION

## Theoretical calculations

A lot of methods have been developed to evaluate the wettability of a fluid/rock system.
No satisfactory method exists for in situ measurements of wettability, and therefore it is necessary to estimate the wettability from laboratory measurements. The studies have ranged from measuring the contact angle of a tin droplet on a substrate to modifying the surface at the nanometer scale to observe super hydrophobic effects to studying the wettability using a scanning electron microscope [11]. Contact angle measurement is a classical method widely used to derive the wettability in a three-phase system (gas/liquid/solid, or liquid/liquid/solid).
The measurement of contact angle is simple in concept, but in practice, it is a very complex topic and the interpretation of results is not straightforward [8].

$$\theta = 2\tan^{-1}[\frac{2H}{D}].$$

Where H the height of the droplet, D diameter of the droplet.

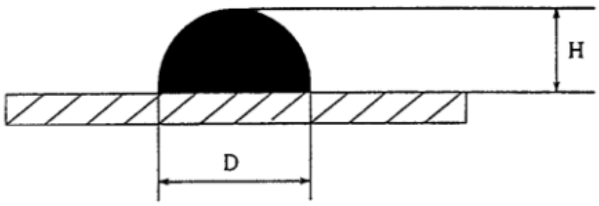


**Figure.** The dimensions of the drop image are used to calculate the contact angle in the system.

The cluster wants to contract as a result of the surface tension. The force affecting from the outside redresses the balance.

## Experimental Results

From Figure 1, it can be seen that the values of the droplet masses differ significantly from each other, it follows that the value of the contact angle can be influenced by the size of the cluster.
As can be seen from Figure 1b the presence of both large and many small particles is observed on the sample surface. The increase in cluster size as the surface temperature was heated above the melting temperature of Sn ($T_s$=250 °C > $T_m$=232 °C) may well have been due to a greater accumulation of promoter molecules on the surface.

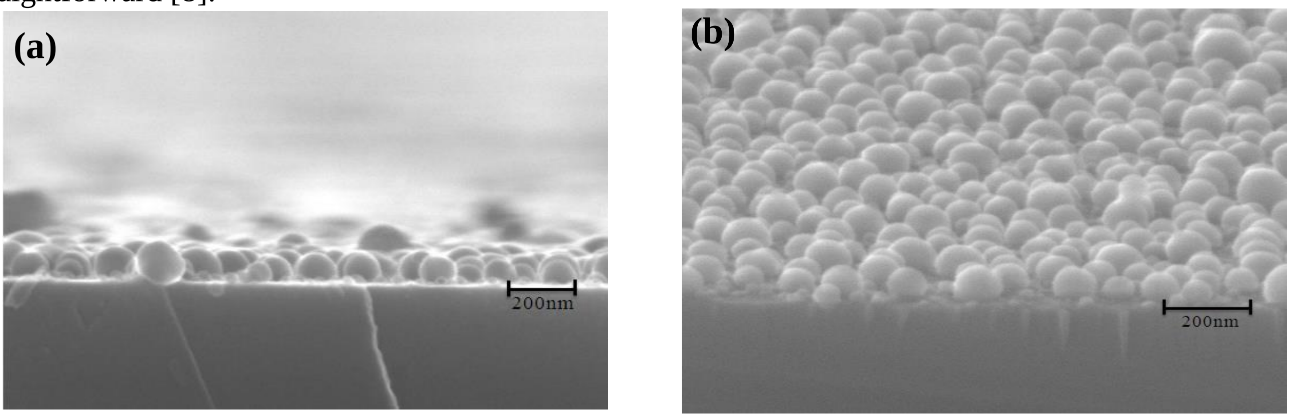


**Figure 1.** Field emission scanning electron microscope.

The cleavage method [9, 10] is based on measuring the parameters of the droplet in a plane perpendicular to the substrate surface Figure 1a. In this case, all three parameters R, d, and H can be easily measured, and the angle θ is determined by the relationship. Since the particle size distribution is characteristic during vacuum condensation, in the cleavage plane there is always a sufficient number of particles for measurements by graphical averaging of the corresponding linear dependences, which makes it possible to minimize the measurement errors of the particle parameters Figure 2.
To find the angle θ, it is sufficient to measure any two of the three quantities characterizing drops on the substrate: the radius of curvature of the drop surface R, the diameter of its based, and the height H Figure 1a.

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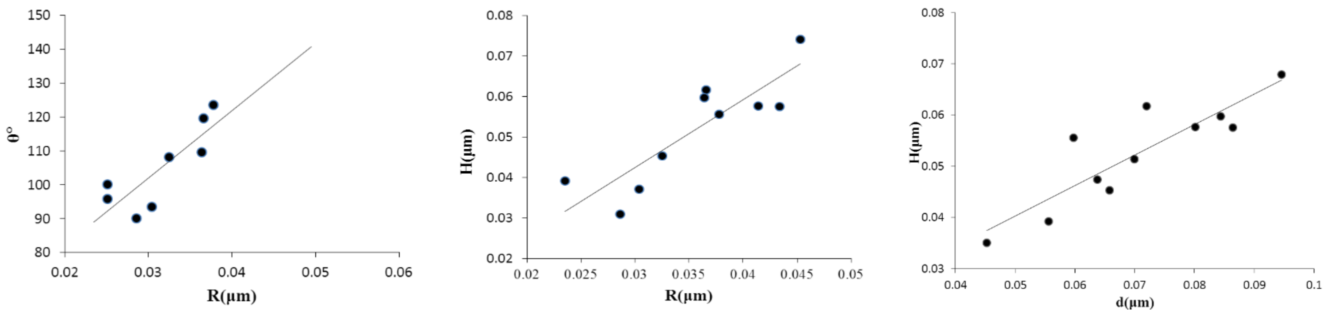


**Figure 2.** Dependences H /R, H/d, and θ/R for drops on a substrate

The sphericity of droplets is also confirmed by comparing the measured droplet height with the value calculated through R and H (Fig. 2). Surfaces of liquids are minimized areas i.e. the amount of liquid tries to minimize the potential energy. This explains the spherical shape of the clusters. The change in wetting properties is due to a change in the surface energy of the material.

The chipping also imposes restrictions on the materials used as substrates, since the substrate must be such that it can be broken or chipped without damaging the microparticles on it.

## CONCLUSIONS

The experimental data presented and their analysis show that the study of wetting has made it possible to obtain many results that are of fundamental importance for surface physics and the physic chemistry of surface phenomena. We also saw that the adhesion is good when the temperature is 250 °C for substrate, through the spherical particles on the surface of the substrate, and by studying the contact angles. These results are important for the theory and practice of phase transformations. First of all, this relates to the detection, detailed study, and theoretical description of the size effect when the surfaces of solids are wetted by small liquid particles.

This work shows that the contact angles on a substrate vary considerably. This is due to variations in impurities and homogeneity. All these properties will affect the resulting measured contact angle.

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