Superficial tension contact angle measurement by image analysis

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This work describes a method for the measurement of the contact angle arosen from the superficial tension of a water drop and a substrate surface. This angle value is related to the affinity of a substrate surface and water and is a valuable knowledge in microelectronic process characterization [1]. If the angle measure is greater than or equal to 90°, then the surface has a hydrophobic character. Conversely, for angle values lesser than 90°, the surface would be hydrophilic (see **Fig. 1)**. In the former case the suplement of the angle is sometimes used to denote the hydrophobic degree, thus also giving a value smaller or equal 90°.

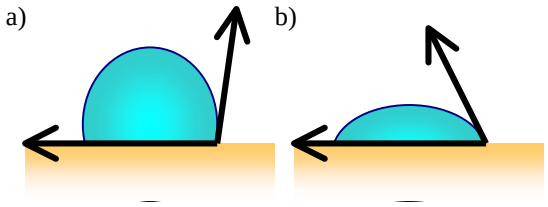

Figure 1 – Contact angle measurement conventions: a) hydrophobic and , b) hydrophilic surface.

The method consists in taking a very contrasted image of a water drop previously deposited over the surface substrate and, after image enhancement and thresholding, a binary image is obtained. The angle is thus determined in this later binary image.

Fig. 2 depicts two examples, the first one of a hydrophobic film (a and b) and, the second, a hydrophilic one (c and d). The raw images first obtained are in (a) and (c) and the final results after the enhancement and thresholding procedures, are in (b) and (d).

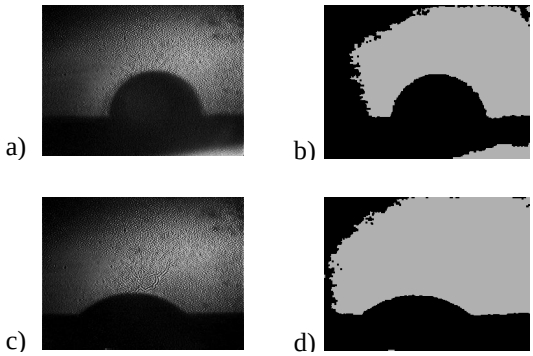

Figure 2 – Raw images (a) and (c) and corresponding processed ones, (b) and (d) respectively. The images (a) and (b) correspond to a Silicon oxide film modified with HMDS and (c) and (d) to a nitrite film.

The raw images were obtained with the experimental setup shown in **Fig. 3**. The film to be characterized is fixed on a pedestal between two flat mirrors, one set vertically and the other slanted by an angle of 45°. Carefully, a water drop is dripped upon the film surface. This whole ensemble is then put under the objective of an optical microscope, with a video camera mounted on its ocular. The microscope own lighting is directed to the slanted mirror, which gives the reflected light rays a horizontal trajectory, crossing the water drop and reflecting on the vertical mirror. This second mirror enhances the contrast of the water drop against the background. The image taken with the video camera is digitized with a frame grabber and further processed.

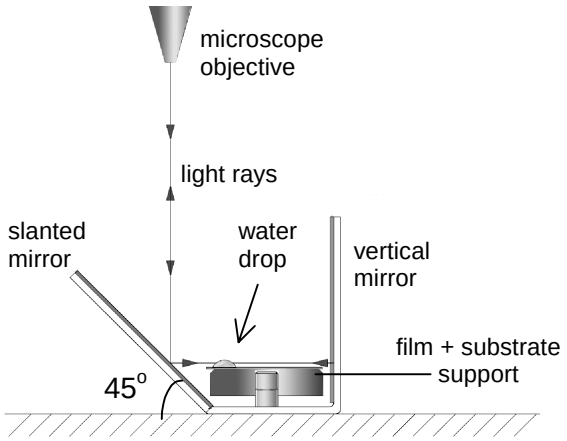

Figure 3 – Experimental setup for contact angle measurement.

The image processing steps are: (i) chromatic transformation to extract the hue map (this would not be necessary with a monochrome camera), (ii) lookup table mapping to logarithmic scale, (iii) binarization by global thresholding, (iv) morphological filtering (recurrent opening) and (v) fill holes. The contact angle is then measured interactively by the operator, by simply placing the sides of the angle over the resulting binary image using the computer mouse pointer. The angle value is found automatically by the program.

This method is a very low cost technique which employs equipment usually found in microelectronics characterization laboratories and uses standard methods for image capture and processing.

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References

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