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# Application Report

## Characterization of Microscopically Small Surfaces

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Author: TS, Dr. Jan-Gerd Frerichs, Dominik Hennemann
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Method:

Drop Shape Analyzer – DSA100M

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# Landing on the Point or Characterization of Microscopically Small Surfaces by Means of Contact Angle Measurement

## Abstract

Please have a brief look at a full stop mark in a newspaper text. Can you imagine dosing 20 to 30 drops on an area this size and measure the contact angle? Or imagine the tip of a nail – even on this microscopically small area tiny little drops can be dosed and measured. Such measurements are currently possible with the innovative micro-dosing system of the contact angle measuring system DSA100M, which is able to dose precisely and on a point, very small drops down to a few picoliters.

The following experiments show the potential of the new Micro-Dosing System DSA100M and may inspire you to new ideas.

## Introduction

On the 29th of December 1959, the physicist and later holder of the Nobel prize, Richard Feynman gave a lecture on: „There's Plenty of Room at the Bottom" at the annual general meeting of the American Physical Society at the California Institute of Technology (Caltech). He spoke about the possibility of manipulation and control of things of a very tiny scale as well as about its theoretical realization. Even at that time, people thought about the miniaturization of systems.

Since the late 1960s, much could be achieved in this field especially in electronics. Electronic instruments such as computers today do not need a complete room for being installed. Mobile phones or storage media like USB-sticks are meanwhile constructed in such a compact way that they fit into a trouser pocket. This progress among others was made possible because the measuring technique enabled us through the course of the years to advance into smaller, miniaturized worlds. Today, kinetic procedures like the formation and rupture of chemical bonds which take place within Femtoseconds ($10^{-15}$ s) can be observed [2], or single molecules can be detected with instrumental analysis [3-5].

The contact angle measuring technique these days also contributes to „miniaturization". The novel micro-dosing system, a new component to the modular measuring system DSA100, has been developed especially for very small sample surfaces. It is in the position to dose drop volumes of only a few picoliters on a point. The following performances shall illustrate the potential of the DSA100M by means of three chosen examples which shall inspire you to new ideas.

## Experimental part

Within the range of this work, the wetting behavior of water on different, microscopically small surfaces was to be determined exemplarily by means of optical contact angle measurement by using the measuring system DSA100M of KRÜSS GmbH (see picture 1).

Picture 1: Drop Shape Analysis System DSA100M of KRÜSS GmbH

The DSA100M is composed by following main components:

- Basic instrument: Contact angle measuring system DSA100
- Optics: 6 fold zoom lens with 20x microscope objective, operating distance 20 mm, min. Field of View 150 µm
- Illumination : High-Power LED Illumination
- Dosing modules: Piezo dosing for drops down to picoliters
- Detection: the available optical systems ensure image acquisition speed from 25 up to 1000 fps (fps = frames per second)

The image acquisition speed of the following examples always was in the range of 250 frames per second, because the evaporation rate of extremely small drops is very high.

The standard test liquid used was water (Table 1).

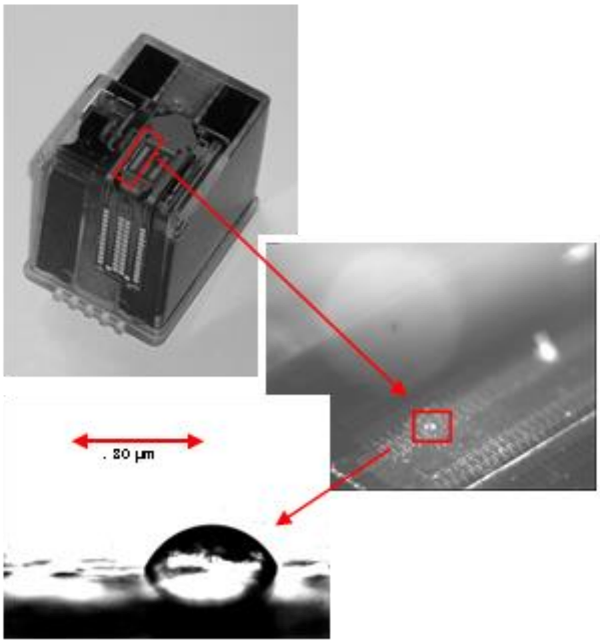
| Liquid | [mN/m] | [mN/m] | [mN/m] |
|---|---|---|---|
| Water | 72.80 | 21.80 | 51.00 |

Table 1: Data of test liquid water according to Ström [6]

## Results and Discussion

### Analysis of the wetting behavior of the dosing head of an ink cartridge

Using the Contact Angle Measuring System DSA100M, it is possible to analyze the surface of dosing heads of ink cartridges with regard to their hydrophilic or hydrophobic properties. In general, the hydrophobic print head surface should be more suitable for the use of an ink cartridge than a hydrophilic surface, as water-based inks, due to weak interactions, produce discrete drops and more easily come off the dosing head.



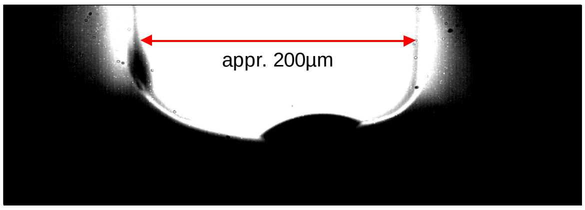
Picture 2: Water drops (Vol: approx. 100 pl) on the dosing head of an ink cartridge. The image acquisition speed of the camera was 250 fps.

Picture 2 clearly shows the microscopically small area (approx. 80 µm), that is covered by the water drop on the dosing head. In this example, a water contact angle of Θ = 66.2° was measured.

### Analysis of wetting behavior in capillary cavities

Another possible application of the DSA100M Contact Angle Measuring System is the evaluation of the wetting behavior of liquids in capillary cavities or depressions. In picture 3, a water drop example is shown in a microscopically small sawn „Canyon" with a width of approx. 200 µm and a depth of approx. 2 mm. The drop volume in this case also was approx. 100 pl.

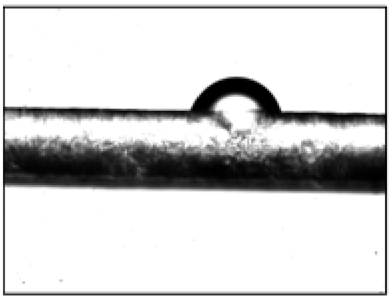
With the DSA100M, we are now in a position to evaluate the success or failure of surface treatment processes (e.g. plasma treatment) in capillary cavities.



Picture 3: Water drops (Vol: approx. 100 pl) in a sawn slot with a width of approx. 200 µm. The slot showed a depth of approx. 2 mm.

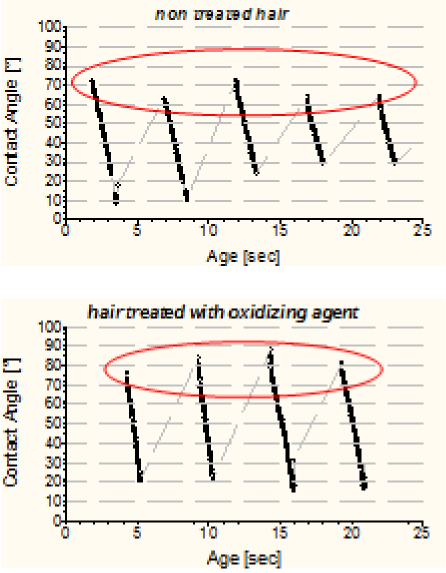
### Characterization of curved, fibrous material

With the last case study, we will show that also the characterization of curved, fibrous surfaces on microscopic level is possible by means of the contact angle measuring technique. As an example, we compared a healthy, untreated hair with a hair that had been treated with an oxidizing agent over several hours. Picture 4 shows a water drop of approx. 100 pl on a single human hair with a diameter of approx. 150 µm.



Picture 4: Water drop (Vol: approx. 100 pl) on human hair.

Picture 5 shows the contact angles measured with the DSA100M on non-treated hair (above) and the hair treated with oxidizing agent (below) depending on the total measuring period.



Picture 5: Contact angle measuring data of five water drops of approx. 100 pl applied at intervals of 5 s, on non-treated hair (above) and of four water drops of approx. 100 pl on hair treated with oxidizing agent in dependency of the total measuring period. The image acquisition speed of the camera was 250 fps.

The zigzag run of the gradient results from:

a) The combination of fast evaporation and penetration of the liquid into the hair (sharp decline of the contact angle within 1 – 2 s).

b) The repeated application of new liquid drops (abrupt rise of the contact angle data)

To judge both hairs, you may consult the average value of the contact angles measured immediately after application of the water drops on the fiber (top of the peak in both diagrams of picture 5, see red marks). In case of the non-treated hair, we obtain a water contact angle of $\Theta = 66.0° \pm 4.5°$ and in case of the hair treated with oxidizing agent, a water contact angle of $\Theta = 82.3° \pm 4.8°$. The hair treated with oxidizing agent over a period of several hours thus shows a more hydrophobic behavior than non-treated hair.

## Summary

Using the innovative Micro-Dosing Systems DSA100M, another component of the modular measuring system DSA100, the ability to analyze the wetting behavior on different microscopically small solid surfaces can be tested. Therefore, contact angle measurements on water drops of approx. 100 pl were carried out. With three case studies, we could show that it is not only possible to characterize plane surfaces but also three-dimensional formed surfaces on a microscopic level with regard to the wetting behavior of liquids.

## Literature

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