Optical Monitoring Method of Sessile Droplet Evaporation

V. Tishkova[1], R. Grossier[1], S. Veesler[1]
1. Aix Marseille Univ, CNRS,
Centre Interdisciplinaire de Nanoscience de Marseille (CINaM),
Marseille, France

Introduction: In the present work we propose a new method of optical monitoring to determine the evaporation mode of a sessile droplet with transmission optical imaging system. There are two main modes: constant contact angle (CCA) and constant contact diameter (CCD) (Figure 1). An intermediate stick-slip mode combines the two modes[1]. Figure 2 represents experimental time sequence of water droplet evaporation [2].

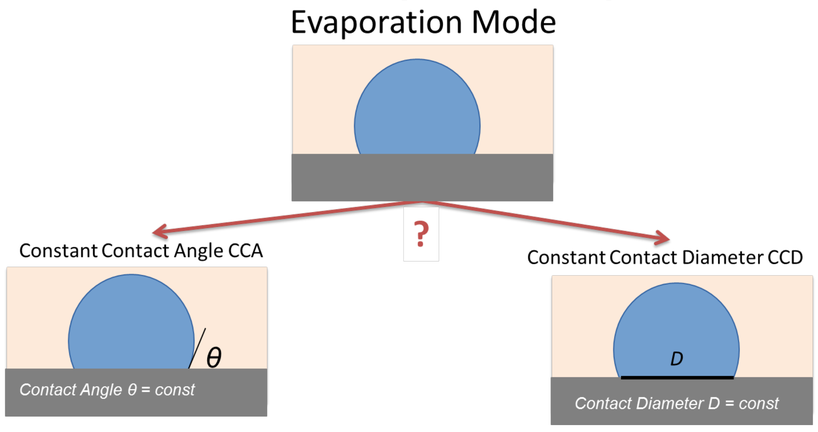

Figure 1. Basic evaporation modes of a droplet.

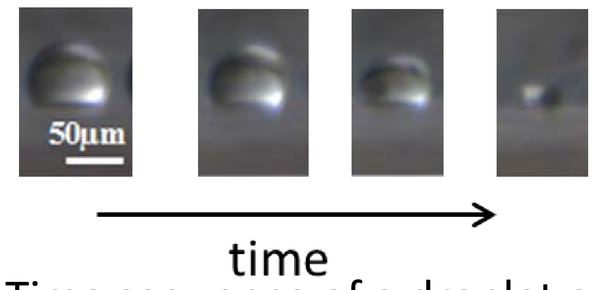

Figure 2. Time sequence of a droplet evaporation[2].

Computational Methods: We use Ray Optics Module of COMSOL Multiphysics® in order to obtain ray trajectories in a micrometer-sizes liquid droplet deposited on a substrate and covered by paraffin oil. The intensity of the light is collected on the liquid-solid interface (see Figure 2) and an optical image is obtained by 360 degree rotation along the axe of symmetry (Figure 3). We simulate pure CCA and CCD modes of droplet evaporation by geometry change.

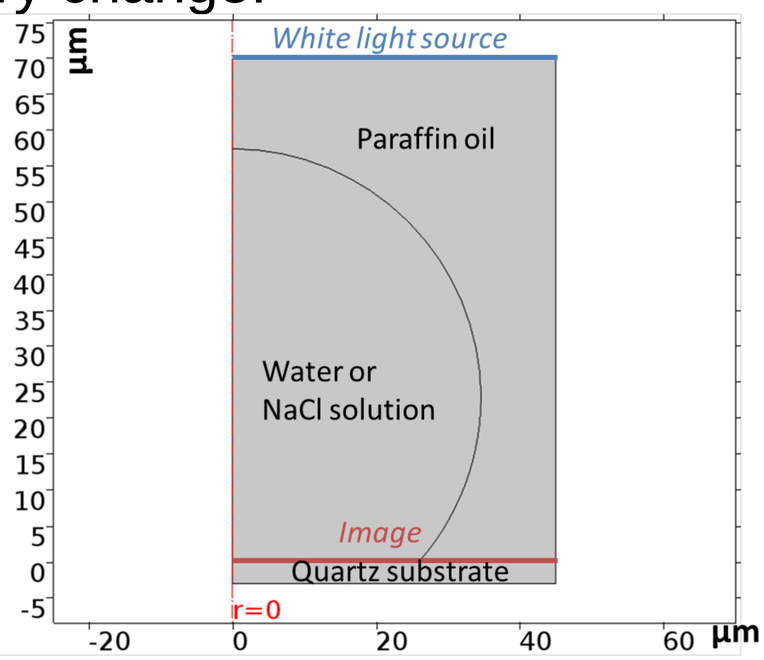

Figure 2. Axisymmetric geometry of a drop. White light source is situated on the top. Intensity is collected on the liquid-solid interface

We compare the standard deviation of the averaged grey level intensities of simulated and experimental images (figures 3 and 4) in order to distinguish between the evaporation modes.

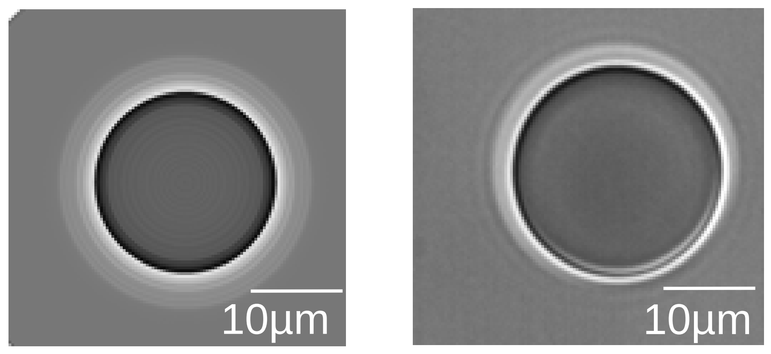

Figure 3. Simulated (left) and experimental (right) transmission optical image of a droplet

Results: Our first results on a water droplet show that standard deviation can be used as a measure of the evaporation mode. We compare the simulated results with the experiment [2] and come to the same conclusion: first the droplet evaporates in CCD mode (step I) and next in mixed mode (step II).

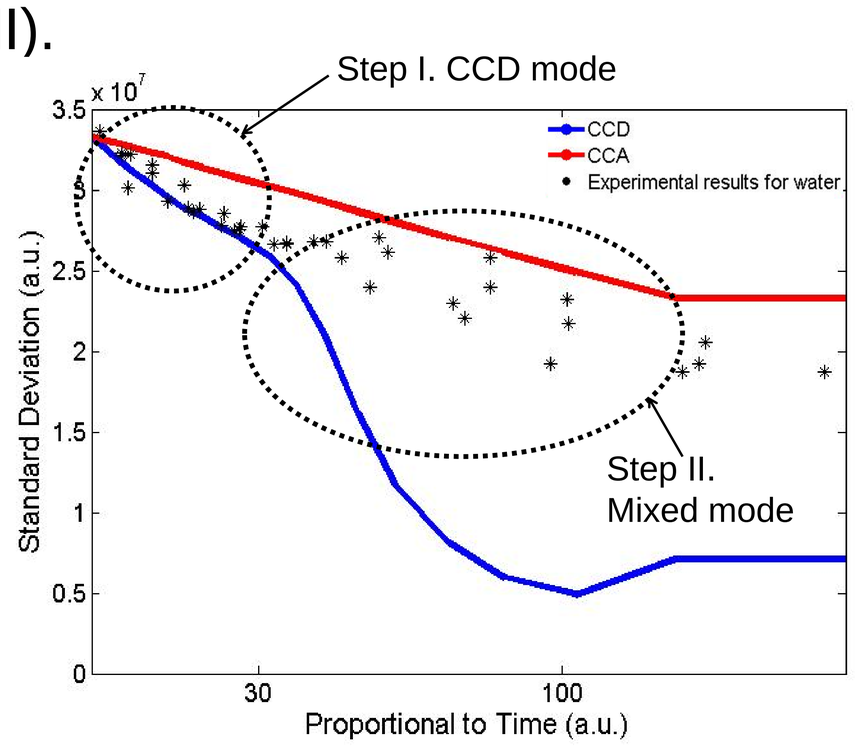

Figure 4. Standard deviation evolution with time for pure CCA and CCD modes (red and blue lines correspondingly) and experimental results for 4 water droplets [2].

Conclusions: Numerical simulation show that the standard deviation of the averaged grey level intensities of an image can be used in order to determine water droplet evaporation mode from the transmission optical image.

References:

1. C. Bourges-Monnier, M. E. R. Shanahan, Influence of Evaporation on Contact Angle. Langmuir, 11 (7), 2820-2829 (1995)
2. I. Rodriguez-ruiz, Z. Hammadi, R. Grossier, J. Gomez-morales, S. Veesler, Monitoring Picoliter Sessile Microdroplet Dynamics Shows That Size Does Not Matter, Langmuir 29 12628-12632 (2013)

Excerpt from the Proceedings of the 2017 COMSOL Conference in Rotterdam