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An interferometric method to measure the shape of (liquid) interfaces with high spatial resolution

Abstract

The method enables the measurements of liquid interface deflections with high spatial resolution – in the range of 10^{-8} m vertically and 10^{-5} m laterally – with temporal resolution of ms. It can for example be used to unravel the capillary adsorption of particles or the wetting and dewetting dynamics of thin liquid films with applications for micro- and nano- technologies, especially for etching or coating processes.

BACKGROUND

Precise measurement of liquid–interface deflections is a key challenge in industrial processes where capillary adsorbed particles, thin liquid films and wetting play a decisive role. In electronics production, processes such as wet etching, photoresist coating, and cleaning rely on controlled liquid layers whose stability and uniformity directly affect reliability. Similarly, in large-scale coating operations for displays or optical films, surface ripples or uneven film thickness can lead to defects and costly waste.

State-of-the-art methods (optical microscopy, profilometry, laser vibrometry) suffer from resolution trade off. High spatial resolution (nm) can only be obtained on small field of view or at single points. For larger areas in the range of mm^2 to cm^2, resolution remains coarser in the µm range. Furthermore, many techniques are based on scanning, which does not allow to capture fast dynamic at the ms – even for limited areas.

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The invention relies on the principle of heterodyne interferometry. By spatially modulating the interferograms, it is possible to apply digital filtering in the frequency space and thus to eliminate undesired low and high frequencies noise, leading to a vertical resolution well below the one of classical interferometers. Interferences are produced by overlapping a reference laser beam with a disturbed beam that is either transmitted through or reflected by the liquid interface to image. The expansion of the beam provides the typical area that can be simultaneously measured. The measurements consist of recording interference patterns with high speed imaging, which fixes the temporal resolution of our method. The data then need to be digitally analysed to provide the dynamic of the liquid film at the rate of the high-speed camera with vertical and horizontal resolutions in the range of 10^{-8}m and 10^{-5}m for over the imaged domain. The measurement principle allows for the subtraction of background noise caused by imperfect optics which can be recorded in a reference image, i.e. when the interface is at rest.

ADVANTAGES

- High spatial resolution: 10^{-8}m vertically, 10^{-5}m laterally
- High temporal resolution: kHz or more depending on used camera
- Large domain mm^2 to cm^2 depending on beam expansion and camera field of view
- Applicable both in transmission and reflection (not transparent films)
- Low sensitivity to background noise via subtraction of a reference image

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KEYWORDS:
Liquid interface
Nanometer
Millisecond
Thin film
Contact angle
Wetting
Coating
Liquid meniscus

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COOPERATION OPTIONS:
License Agreement
Transfer of Rights
R&D Agreement

DEVELOPMENT STATUS:
Laboratory prototype

STATUS OF PATENTS:
EP Application filed

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