Fluid Imbibition-Coupled Laser Interferometry: a highly sensitive optical technique for nanometrology

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Abstract

Fluid imbibition-coupled laser interferometry (FICLI) is a technique recently introduced [1] consisting of the registration of the interference pattern produced by a laser beam reflected off the two interfaces of a nanoporous anodic alumina (NAA) film, as it is being filled by a liquid front, Fig. 1. As the liquid interface within the nanopores moves, the optical path between the two reflected waves varies leading to successive intensity maxima and minima, Fig. 2. From the analysis of this time-resolved oscillation pattern, geometrical characteristics of the pores can be extracted. This analysis can be done in several different ways [1, 2]. In ref. [1], the radius at each side of the NAA pores can be estimated from the filling time from top ($t_{Fill,Top}$) and from bottom ($t_{Fill,Bottom}$) of the pores. However, the determination of such filling times is affected by a noticeable uncertainty, which propagates into the calculation of the pore radius. In this work, we propose an alternative method for the determination of the radius, based on the analysis of the succession of maxima and minima. Fig. 3 illustrates this procedure: the time differences between two consecutive extremes are plotted against the ordinal of each extremes pair. The slope of the linear regression is related to the radius of the pore, what provides a more robust estimate. In this work, we aim at evaluating the accuracy of the different pore radius determination procedures. Fig. 4 shows the estimated values of top and bottom radius for the two methods, together with the error bars corresponding to the uncertainty, for samples with increasing radius. As it can be seen, the new method provides better accuracy. Furthermore, in Fig. 4, the detection of the binding event of a protein (Bovine Serum Albumin, BSA) to the inner pore walls of the NAA is demonstrated as a reduction in pore radius.

References

[1] R. Urteaga et al., Langmuir, **29** (2013) 2784.
[2] E. Elizalde et al., Physical Review Letters, **112** (2014) 134502.

Acknowledgements

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Figures

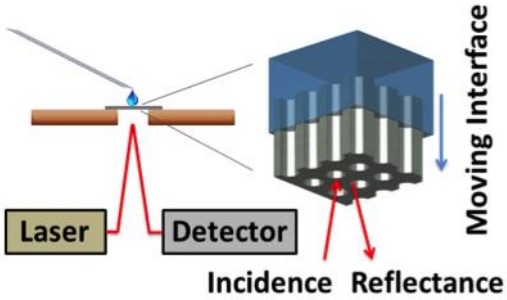

Figure 1: Scheme of the technique.

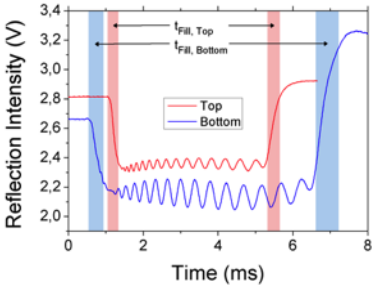

Figure 2: Example of the measured magnitude.

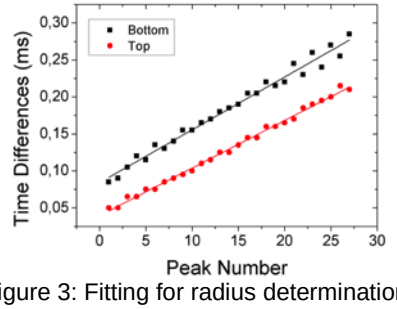

Figure 3: Fitting for radius determination.

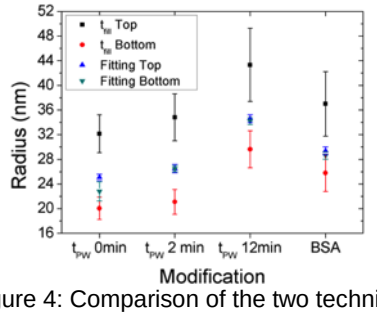

Figure 4: Comparison of the two techniques.