# Cavity-Based methods for precise, real-time refractive index measurements

**A.K. Spiliotis[1,2], D. Sofikitis[1], G.E. Katsoprinakis[1] and P.T.Rakitzis[1,2]**

[1]IESL-FORTH, N. Plastira 100, 71110, Heraklion, Crete, Greece
[2]Department of Physics, University of Crete, 71003, Heraklion, Crete, Greece

Email: spiliot@iesl.forth.gr

P3-44

Measuring the index of refraction of liquid, gas and solid substances is important for various scientific and industrial fields, including semiconductors science, analytical chemistry and medicine. Ellipsometry is the most widely used technique for the measurement of the refractive index. However, this 100-year old technique has severe limitations related to time resolution (close to 1 s for high accuracy measurements ($10^{-3\circ}$) and can reach the millisecond range with reduced accuracy. The combination of ellipsometry with cavity techniques, demonstrated in [1] allows much higher sensitivity and/or time resolution. The ellipsometric phase shift is enhanced by the number of passes and is imprinted in the frequency of a beating superimposed on a normal CRD signal. This phase shift is directly related to the refractive index of the sample. Eversince, Cavity Ring-Down Ellipsometry (CRDE) has been used to measure the adsorption of gases [1], and liquids and surfaces [2], probing via the evanescent wave formed at the interface between the sample and a total internal reflection (TIR) prism.

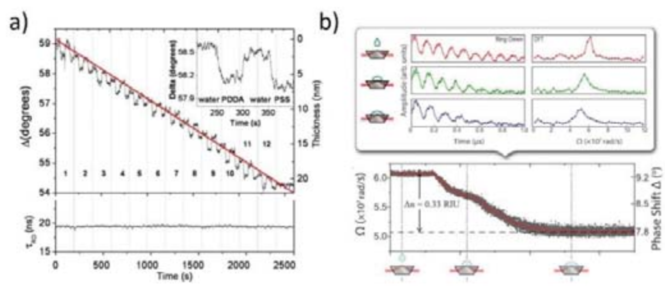

**Figure 3** a) Detection of nm-sized dielectric layers b) Real-time monitoring of droplet spreading.

An example of the sensitivity achieved (~$6*10^{-3\,\circ}$) with CRDE is shown in Fig.1.a, where we see the real-time observation of the creation of nm-sized dielectric layers [3] created by layer-by-layer deposition. In the inlet we see the modification of the beating frequency each time a different electrolyte or brine is inserted on the interface. After such a succession the beating frequency reduces by a certain amount, indicating the creation of a new dielectric layer. An example of the time resolution accessible with CRDE is given via a wetting experiment [4] which results are shown in Fig.1.b. In the upper part we see the CRDE signals, as well as their corresponding Fourier transforms before, during and after wetting the upper surface of the TIR prism. In the lower part we see the evolution of the beating frequency during the wetting process. Note that the time resolution is 2 μs for a sensitivity of ~$2.6*10^{-2\,\circ}$. These are, to our knowledge, the fastest running ellipsometric measurements to date. Coupling this technique to monitoring techniques such as HPLC can produce fast and accurate instruments for the measurement of liquid samples.

## References

[1] Karaiskou et al., The Journal of Chemical Physics 131, 121101 (2009); doi: 10.1063/1.3236819
[2] Everest et al., Evanescent-Wave Cavity Ring-Down Ellipsometry, J. Phys. Chem. Lett. 2011, 2, 1324–1327
[3] Sofikitis et al., Sensitivity enhancement for evanescent-wave sensing using cavity-ring-down ellipsometry, Opt. Let., Vol. 38, No. 8, 2013
[4] Sofikitis et al., Microsecond-resolved SDR-based cavity ring down ellipsometry, Appl. Opt., Vol. 54, No. 18, 2015