

## Integrated photonic devices for sensing application : toward viscosity analyses by resonant signal measurements

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### Abstract

The understanding and analyzing of solid particle behavior in a liquid is a challenge in numerous fields and engineering industry as the petroleum or the cosmetic one. It is indeed essential to know the behavior of soft matter process to avoid problems and ensures the product quality. This study presents the viscosimeter development working on a resonant optical signal principle by measuring the Free Spectral Range (FSR) parameter of a resonant optical mode during nanoparticles (NPs) sedimentation in a liquid which consists of a water/glycerol mixture. The photonic structure is composed of racetracks micro-resonators made of a UV210 polymer fabricated by deep-UV photolithography developed on an oxydated silicon layer to get a Si/SiO<sub>2</sub> bi-layer. The chip is then integrated in an optical bench to track the evolution of the FSR during the complet sedimentation process. The resonant signal analyse established by an adapted signal processing of silica nanoparticles sedimentation in different water/glycerol concentrations allows us to determine stages and velocity rate of the sedimentation process to finally access to their viscosity. At the same time, measures are performed on a commercial mechanical rheometer so as to compare the dynamic evolution of their viscosity and their associated FSR. The plot of those data versus the glycerol concentration in water obviously shows a possible mathematical transformation between viscosity and FSR slope. There is therefore a good agreement between mechanical and resonant optical measures ; so this work proves the feasibility of an optical viscosimeter based on resonant signal.

**Keywords:** Integrated photonics and resonators, optical characterizations, viscosity and sedimentation, soft matter, surface resonant signal processing, rheology.

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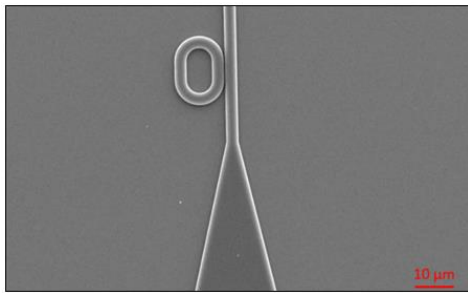
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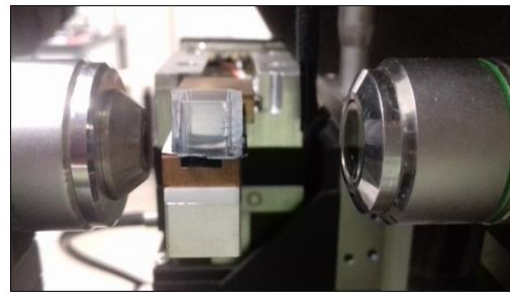
### 100 words for summary program:

This study presents the viscosimeter development working on a resonant optical signal principle by measuring the Free Spectral Range (FSR) of an optical mode during nanoparticles sedimentation in a water/glycerol mix. The photonic structure is composed of racetracks micro-resonators made of a UV210 polymer developed on a Si/SiO<sub>2</sub> bi-layer. The plot of the viscosity (measured by a mechanical commercial rheometer) compared to the associated FSR slope during sedimentation versus glycerol concentration show a possible mathematical transformation between those data. The good agreement between mechanical and optical measures proves the feasibility of an optical viscosimeter based on resonant signal.

Some Figures (few examples):

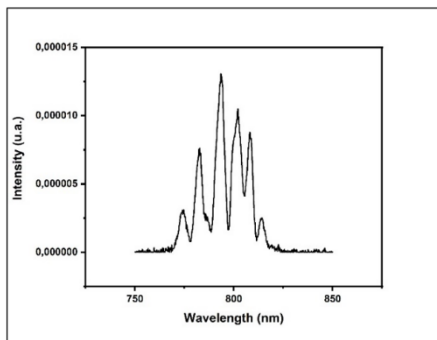


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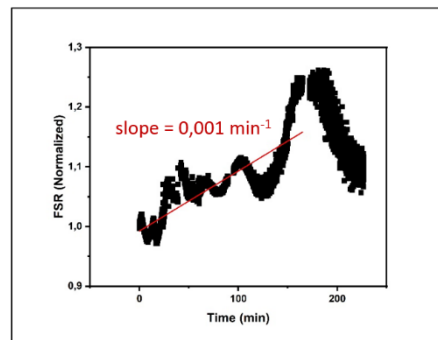


b)

**Figures :** a) MEB image of the MR and taper geometry b) Photography of a tank containing solution with NPs above the photonic structure during sedimentation process.

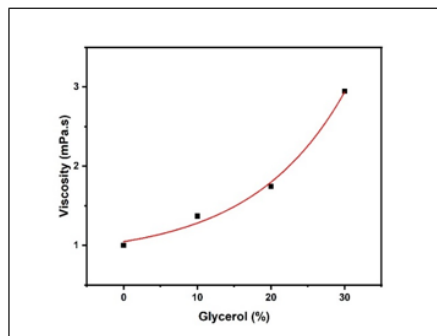


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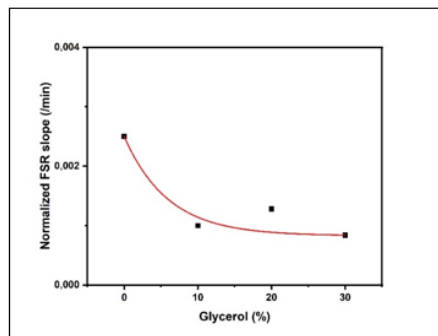


b)

**Figures :** a) Example of the transmitted resonant signal b) Normalized FSR versus time during a sedimentation process in a water/glycerol mix (90/10).



a)



b)

**Figures :** a) Solutions viscosity measured by a mechanical commercial rheometer versus glycerol concentration b) Comparison with normalized FSR slope parameter of the photonic resonance versus glycerol concentration.