Sputtering of silver onto silicone oils: nanoparticle formation and mass transfer into the bulk solution

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Abstract

Nanoparticles (NPs) synthesis by low-pressure plasma-base sputtering onto liquid offers many advantages. However, the NP formation mechanism and the viscosity effect are not well understood. Here, an operando absorption spectrophotometry is used to record time- and space-resolved spectra of colloïdal solution. In this work, silver atoms are deposited onto still silicone oil with different viscosities (20, 50 and 100 cSt). Analyses were carried out during sputtering (Plasma ON time) and afterwards (Plasma OFF time).

Magnetron sputtering and set-up

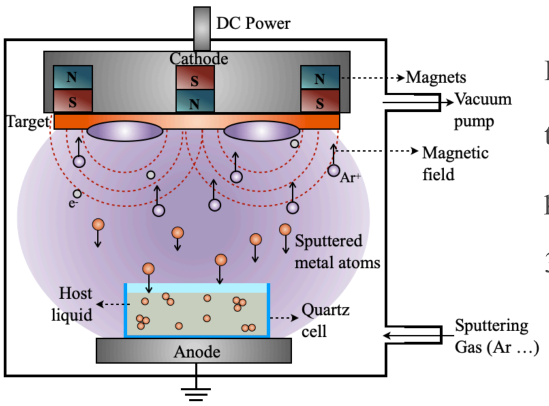

Fig 1. Illustration of the magnetron sputtering process onto liquids (SoL).

Deposition parameters

P = 10 W

t_s = 5 min

p = 0.5 mTorr

3 silicone oil viscosities:

- 20 cSt
- 50 cSt
- 100 cSt

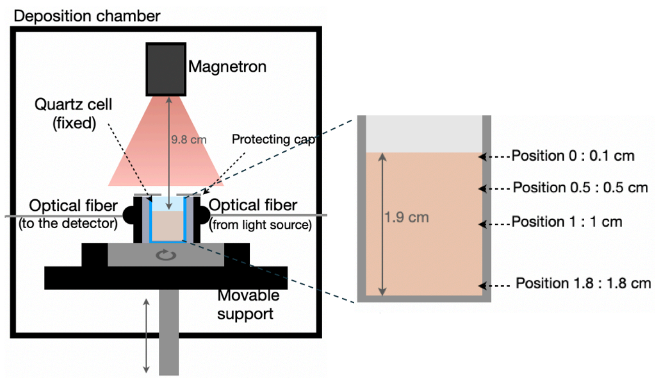

Fig 2. Schematic diagram of the experimental setup.

Results

Plasma ON Time

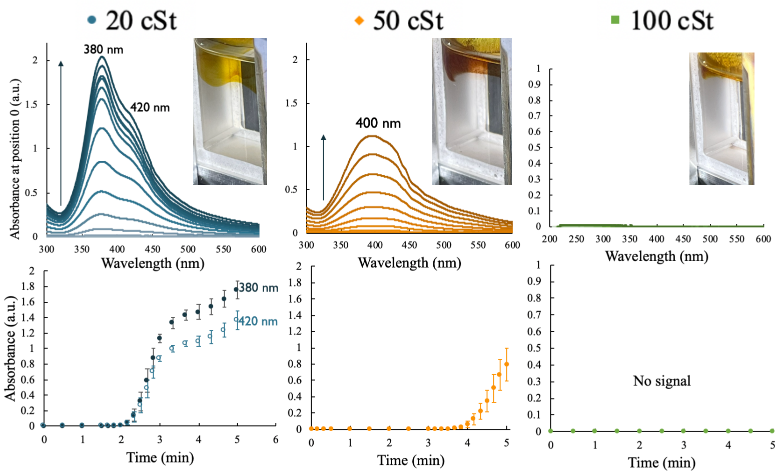

Fig 3. UV-Visible spectra of Ag-NPs during the sputtering process (Plasma ON Time) and evolution of absorbance over time for the three silicone oil viscosities.

First absorption signal depend on viscosity and position:

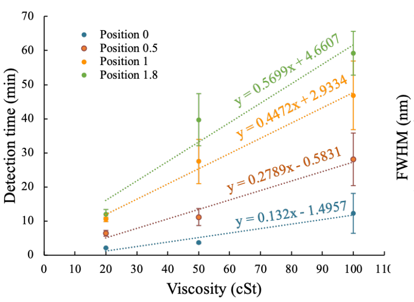

Fig 5. Evolution of the detection time as a function of the viscosity for each position of the optical fibres

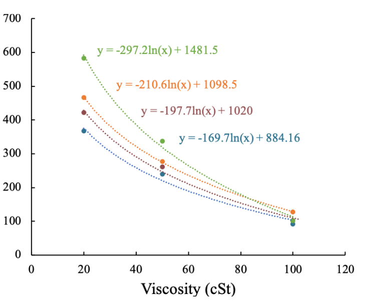

Fig 6. Evolution of the FWHM as a function of the viscosity for each position of the optical fibres (75 min after sputtering).

→ Detection time increases linearly with the oil viscosity

→ FWHM decreases with the oil viscosity

Plasma OFF Time

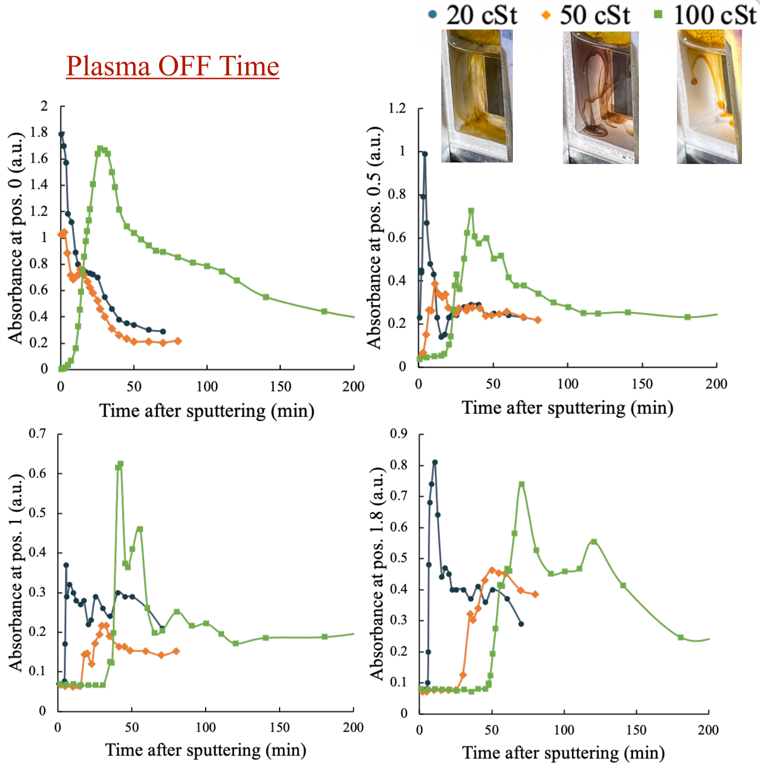

Fig 4. Evolution of the absorbance maximum after the sputtering period (plasma OFF Time) for the three viscosities of silicone oil and for each position of the optical fibres

Conclusion

→ Diffusion of the nanoparticles towards the bulk of the solution is slower as viscosity increases

→ Viscosity influence the size NPs distribution and the aggregation process:

- Size decreases with viscosity (Data confirmed by DLS)
- Aggregation process is more important for high viscosity

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