Designing of Plasmonic Resonators for Artificial Optical Magnetism

Sekar [1], M. Nour Mahamoud [2], F. Gauffre [2], A. Baron [1], V. Ponsinet [1], O. Mondain-Monval [1]

1. Ce ntre de Recherche Paul Pascal (CRPP), UMR CNRS 5031, University of Bordeaux, 33600 Pessac
2. Institut des Sciences Chimiques de Rennes (ISCR), UMR CNRS 6226, University of Rennes, 35042 Rennes

sribharani.sekar@crpp.cnrs.fr

Over the past decades, meta-materials & surfaces have attracted huge attention due to their emergence as a powerful platform for enabling advanced optical functionalities, owing to their exceptional wave propagation properties, which are not found in naturally occurring materials [1]. Metamaterials have widespread applications, especially as nanolasers, optical antennas, sensors and for nonlinear optics [2]. Key components of metasurfaces (the 2D version of metamaterials) are the optical resonators that can be constituted of assembled plasmonic nanoparticles. These NPs clusters were shown to exhibit strong magnetic response when interacts with electromagnetic fields, which is referred to as optical magnetism. Moreover, the intensity of this response can be tuned by the clusters structure and density [3].

Here in this work, we have engineered plasmonic nano resonators through bottom-up self-assembly of noble metal nanoparticles. To achieve those clusters, we used two specific methods, namely the Ouzo fabrication route and the emulsion-based route [4]. With this latter one, we now aim at producing monodispersed and reproducible clusters through the use of microfluidics technique, which enables precise control over cluster formation. The clusters were systematically characterized by TEM, DLS and SAXS to determine their morphology, shape and size distribution. Additionally, we have designed plasmonic resonators with specific optical resonance modes in the visible wavelength range through the development of NP-shells [5] via Ouzo route, where gold nanoparticles were self-assembled on Ouzo droplets generated from liquid-liquid phase separation of hydrophobic solutes in a ternary system by the addition of a non-solvent.

Measurement on these two formulated resonators with our home-made Polarization-resolved Static Light Scattering (SLS) exhibit promising signals that corresponds to magnetic scattering of resonators when interacting with light. Our findings demonstrate that these optical resonators will have significant contribution and potential applications in the development of future photonic devices where magnetic responses in the visible range is crucial.

Keywords:
Meta-materials & surfaces, Emulsion, Optical resonators, Microfluidics, Optical magnetism.

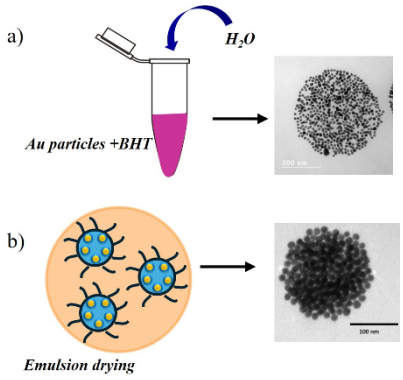

Figure1: Formulation of Plasmonic resonators through a) Ouzo and b) Emulsion route.

References:

[1]. W.J. Padilla et al, Materials Today, 9, 28-35 (2006)
[2]. H. Husu et al, Nano Letters, 12, 673-677 (2012)
[3]. J. Dintinger et al, Optical Materials Express, 2, 269-278 (2012)
[4]. M. Lafitte et al, Langmuir, 40, 2601-2615 (2024)
[5]. C. Goubault et al, Journal of Colloid and Interface Science, 603, 572-581 (2021)

Acknowledgements:
We acknowledge financial support by the French Agence Nationale de la Recherche, under the contract # ANR-20-CE06-0031 and ANR-25-CE06-6949.