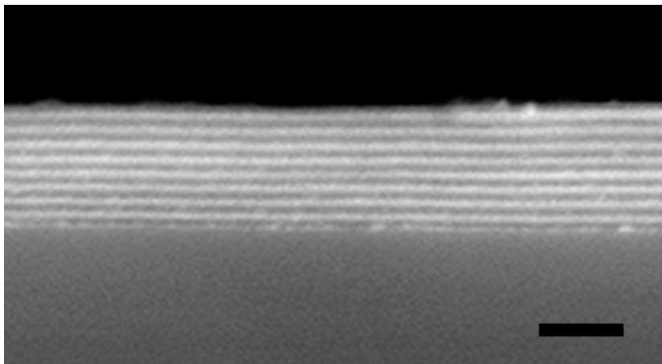# Block-copolymer based self-assembled hyperbolic metamaterials in the visible range

X. Wang[1], K. Ehrhardt[1], M. Kildemo[2], A. Baron[1], A. Aradian[1], V. Ponsinet[1]

1 Centre de Recherche Paul Pascal, Univ. Bordeaux, CNRS UPR 8641, Pessac, France
2 Physics Department, NTNU, Trondheim, Norway

Novel optical properties in the visible range are foreseen when organizing nanoresonators, which can be performed by the self-assembly of plasmonic nanoparticles prepared by wet chemistry. In this project, we prepare and study thin films of nanocomposites of polymers and gold nanoparticles. Our goal is to relate the structure of the composites, and in particular the nature, density and spatial organization of the nanoparticles, with their optical index. The anisotropic nanocomposites are produced by the assembly of gold nanoparticles (NPs) templated by ordered matrices of diblock copolymers. In particular, lamellar nanocomposite films are obtained by self-assembly of poly(styrene)-b-poly(2-vinyl pyridine) (PS-P2VP) copolymers, followed by gold NPs selective incorporation, and studied by X-ray scattering and scanning electron microscopy (SEM). They consist in periodic lamellar stacks of alternating layers of pure polymer (dielectric) and of composite of polymer loaded with a high density of 9 nm-diameter gold nanoparticles, with a total thickness between 200 and 600 nm and the subwavelength characteristic size d_o chosen between 20 and 70 nm. The amount of gold in the composite layers can be varied up to typically 40 volume%.

Backscattering SEM micrograph of the side view of a thin film of a layered gold-polymer nanocomposite, deposited on a silicon substrate. Gold nanoparticle-rich regions appear in white and polymer regions in dark grey. Bar=200nm

The optical properties of the nanocomposite films are determined by variable angle spectroscopic ellipsometry and analyzed by appropriately developed effective medium models. As can be seen on an example shown in the Figure, the films are structurally uniaxial and homogeneous, and we can define their dielectric permittivity tensor with the ordinary (parallel to the substrate) and extraordinary (normal to the substrate) components. The analysis of the lamellar structures allows the extraction of the components ε_o and ε_e, both presenting a resonance close to 2.3 eV, with a significantly stronger amplitude for ε_o. When the gold load is high enough and the couplings between particles are strong enough, the values of ε_o become negative close to the resonance, and the material reaches the so-called hyperbolic regime, which constitutes a step towards applications in hyper-resolution imaging.