Nanooptics of self-organized plasmonic layers for sensor applications

Juris Prikulis, Uldis Malinovskis, Raimonds Poplausks,
Gatis Bergs, Indra Apsite, Donats Erts
Institute of Chemical Physics, University of Latvia, Latvia
e-mail: Juris.Prikulis@lu.lv

Self-organization bridges the gap between top-down and bottom-up nanostructure production techniques. A well-known self-organized material is porous anodized aluminum oxide (AAO), where pore diameter and separation can be tuned by electrolyte solution and the applied voltage. The AAO can then be used as a template for synthesis of other structures, such as metal or semiconductor nanowires.

In a recent work ultrathin AAO masks were used to produce well-defined nanoparticles with small size distribution in sub-20 nm range [1]. They are distributed in a short-range ordered (SRO) array with center separation ~50 nm. Gold and silver SRO systems are of particular interest for optical applications since their localized plasmon resonances occur in visible and near infrared spectral range.

We present a study of optical scattering by dense self-organized nanoparticle SRO arrays where neighboring particles are separated by gaps much smaller than the wavelength of the incident light. Due to short distances the particles couple by optical nearfield. For particle sizes of interest in present study, the optical scattering can be simulated using coupled dipole model [2]. Our simulations predict and experiments confirm that near resonance conditions the SRO arrays scatter light at polarizations, which would be absent in decoupled systems.

We utilize the depolarized light scattering to demonstrate a new type of biosensor, where local environment changes are quantified using analysis of cross-polarized far-field interference patterns. In comparison to colorimetric sensors, the interferometric detection system does not require any spectrometer and can employ simpler optical components designed for single wavelength use. The concept of scattering by aperiodic systems of coupled elements can be generalized for 3D and multilayer structures.

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References

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[2] J. Prikulis, et al. Plasmonics, **9**, 427 (2014)