Plasmonics/metamaterials and crystal growth at the crossroads

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Abstract- We report on developments in fabricating nano and micro-structured volumetric plasmonic materials and metamaterials utilizing crystal growth techniques as the micro-pulling down method. Materials developed by directional solidification of eutectic composites and directional solidification of dielectrics directly doped with functional nanoparticles.

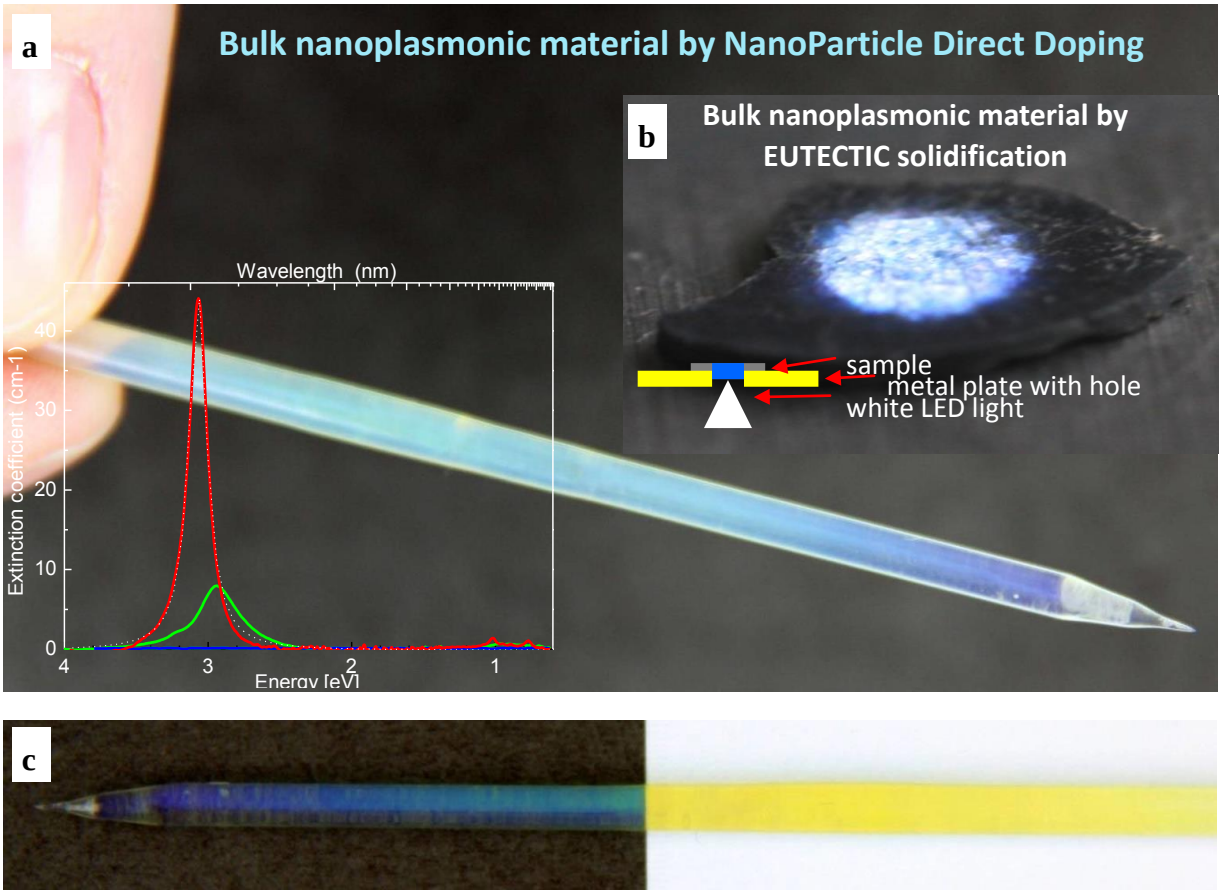

Fig. 1. Demonstration of nanoplasmonic bulk materials obtained utilizing directional solidification/crystallization by the micro-pulling down method. (a) Bulk nanoplasmonic material obtained by doping a glass matrix with Ag nanoparticles utilizing the NanoParticles Direct Doping, NPDD [1]. The localized surface plasmon resonance is at ca. 405 nm, the rod looks blue when observed in the scattered light. (b) Bulk nanoplasmonic material obtained by annealing the Bi_2O_3-Ag eutectic. The LSPR resonance here appears at ca. 595 nm. The blue light is seen in the transmission mode in this case [2].

(c) In this Figure the dichroic effect is seen in the same rod as in (a). In the scattered light the rod appears blue and in the transmitted light the rod appears yellow [1, 3]. The two colours are observed so clearly due to the presence of both: small particles which mainly absorb, and bigger particles which mainly scatter.

Utilizing described above methods we demonstrated (i) volumetric eutectic-based material with localized surface plasmon resonance at visible wavelengths [1, 2]; (ii) enhanced luminescence and up-conversion processes in the eutectic material exhibiting LSPR and co-doped with erbium ions; (iii) volumetric matrix-nanoparticles-based materials with plasmonic resonances at visible and IR wavelengths based on silver (Ag), antimony-tin-oxide (ATO) and titanium nitride nanoparticles (TiN); (iv) matrix-nanoparticles-based composite with enhanced photoluminescence at the telecommunication frequency of 1.5 μm; (v) material with subwavelength transmission at IR frequencies [4]; (vi) material with anomalous refraction, evaluated by the beam deviation measurements [5]; (vii) materials with enhanced Faraday effect; and (viii) materials for phonoanodes in photoelectrochemiacal cells for generation of hydrogen.

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