Novel photonic materials enabled by crystal growth

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Recently, we proposed the idea of utilizing directional solidification as a method for manufacturing metamaterials [1] and plasmonic materials [2]. We develop two methods: (i) method based on directionally-grown self-organized eutectic structures [3-5]; and (ii) NanoParticles Direct Doping method (NPDD) based on directional solidification of dielectric matrices doped with various nanoparticles [6-8]. In both of these methods we can easily use all available resonant phenomena to develop materials with unusual electromagnetic properties. Utilizing described above methods we demonstrated: (i) volumetric eutectic-based material with localized surface plasmon resonance at visible wavelengths [9-10]; (ii) enhanced luminescence and up-conversion processes in the eutectic material exhibiting LSPR and co-doped with erbium ions [6]; (iii) volumetric matrix-nanoparticles-based materials with plasmonic resonances at visible [6, 11] 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 [12]; (vi) narrow band filter and polarizer [13-14]; (vii) surface enhanced Raman scattering in a bulk eutectic material enabling enhancement of selected Raman modes [15], (viii) materials with enhanced Faraday effect; (ix) materials for photoanodes in photoelectrochemical cells for generation of hydrogen [16-17], (x) topological insulator heterostructures. All these results will be described.

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