Bottom-up manufacturing methods for photonics (metamaterials and plasmonic materials)

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In recent years, novel research areas have been developed in the field of photonics: metamaterials and nanoplasmonics. By utilizing the ideas developed in these research areas and using specially-designed materials, unusual electromagnetic properties such as artificial magnetism, negative refractive index, cloaking and squeezing photons through subwavelength holes have been demonstrated. These novel fields need new material fabrication techniques, especially bottom-up approaches such as self-organization. Two novel bottom-up manufacturing methods will be presented based on: (i) directional solidification of eutectic composites and (ii) doping dielectric matrices with plasmonic nanoparticles. Eutectics are simultaneously monolithic and multiphase materials forming self-organized micro/nanostructures, which enable: (i) the use of various component materials including oxides, semiconductors, metals, (ii) the generation of a gallery of geometrical motifs and (iii) control of the size of the structuring, often from the micro- to nanoregimes. On the other hand, the novel method of direct doping of dielectric matrices with nanoparticles utilizing directional solidification may provide three-dimensional nanoplasmonic materials enabling doping with nanoparticles of various chemical composition, various size and shape, as well as co-doping with other chemical agents. In both cases we apply one of the crystal growth methods – the micro-pulling down method – to create the material. Materials with plasmonic resonances at visible and IR wavelengths will be presented, as well as their influence on photoluminescence properties of the optically active materials. Our new approach may lead to novel manufacturing solutions for photonic applications in areas such as metamaterials, plasmonics, as well as photovoltaics and photoelectrochemistry.