Metallodielectric eutectic composite for plasmonic applications

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Abstract-Metallodielectric composites are very interesting from the point of view of metamaterials and plasmonics. For the fabrication of self-organized metallodielectric micro/nanostructures, one particularly promising approach is based on the directional solidification of eutectics. Here we demonstrate a bulk three-dimensional nanoplasmonic eutectic composite which was obtained by bottom-up approach. This material exhibits localized surface plasmon resonance (LSPR) at visible wavelengths.

Materials with negative dielectric permittivities (e.g. metals) at frequencies below their plasma frequency have caused the rapid development of a new research area: plasmonics [1],[2]. It is based on the utilization of the specific electromagnetic effects related to surface plasmons –(collective electron oscillations at a metal–dielectric interface), such as localized surface plasmon resonances (LSPRs) in small particles and the corresponding enhanced local electromagnetic fields . These effects enable the enhancement of materials optical properties such as optical absorption, photoluminescence or optical nonlinearity. Nowadays, the fabrication of bulk three-dimensional materials presenting such enhanced optical response is a very hot topic of research.

Bottom-up manufacturing methods, like self-organization and chemical methods are powerful for obtaining materials with controlled plasmonic properties and metamaterials [3],[4] [5], [6]. One particularly promising approach relies on the growth of self-organized metallodielectric micro- and nanostructures by directional solidification of eutectics. A eutectic is characterized by the formation of two un-mixable crystals from a completely mixable melt. It presents the unusual characteristic of being at the same time a monolith and a multiphase material. Eutectic materials are very promising in the case of plasmonics due to their versatile properties,. It is specially the case for metal-oxide eutectics, the potential of which remains unexplored so far.

In the current work, the manufacturing and optical properties of metallodielectric eutectic-based materials in a self-organization process are discussed. A metal-oxide eutectic has been obtained and characterized. The eutectic was directionally solidified by the micro-pulling down method. This metallodielectric eutectic exhibits LSPR at ~ 590 nm wavelength [7]. We demonstrate the introduction of rare-earth ions to this eutectic material, thus opening the path to important active optical properties, like photoluminescence or up-conversion processes which could be used for efficiency enhancement of ~~in~~ silicon-based solar cells.

Acknowledgements, The authors thank the Maestro Project 2011/02/A/ST5/00471 and the Preludium Project 2012/07/N/ST5/02428 from the National Science Centre, the Project operated within the Foundation for Polish Science Team Programme cofinanced by the EU European Regional Development Fund and the U.S. Air Force Office of Scientific Research under Grant FA9550-14-1-0061 for support of this work. Additional information: The authors have applied for a patent regarding this work.

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