A new way of reducing plasmonic losses

V. A. Fedotov*, J. Y. Ou, N. I. Zheludev
Optoelectronics Research Centre and Centre for Photonic Metamaterials, University of Southampton, UK
* e-mail: vaf@orc.soton.ac.uk

Abstract We report on a novel way of reducing plasmonic losses in noble metals commonly used in the fabrication of photonic metamaterials and plasmonic nanostructures.

Metamaterials is a new class of artificial materials designed to interact with light in ways no natural materials can [1, 2]. The exotic and often dramatic physics demonstrated by the metamaterials is generally underpinned by the light-scattering properties of sub-wavelength metallic resonators (metamolecules) that form metamaterials. Due to its resonant nature the response of the metamaterials is very sensitive to the presence of losses in the constituting metals. The losses are particularly strong in the plasmonic regime (i.e. at optical frequencies) hampering the use of metamaterials for photonic applications. The list of mainstream solutions considered at present includes, in particular, the search for better plasmonic media among metallic alloys, semiconductors and conductive oxides [3 - 5], as well as direct compensation of losses by combining metamaterials with various optical gain media [6 - 8] or use of superconductors [9]. Here we present a new solution, which enables significant reduction of plasmonic losses at the metamaterial fabrication stage and is based on structure engineering of conventional plasmonic materials.

REFERENCES

1. V. G. Veselago and E. E. Narimanov, “The left hand of brightness: past, present and future of negative index materials”, *Nature Mat.*, Vol. 5, 759, 2006.
2. N. I. Zheludev, “The Road Ahead for Metamaterials”, *Science*, Vol. 328, 582, 2010.
3. D. A. Bobb, G. Zhu, M. Mayy, A. V. Gavrilenko, P. Mead, V. I. Gavrilenko and M. A. Noginov, “Engineering of low-loss metal for nanoplasmonic and metamaterials applications”, *Appl. Phys. Lett.*, Vol. 95, 151102, 2009.
4. M. G. Blaber, M. D. Arnold and M. J. Ford, “Optical properties of intermetallic compounds from first principles calculations: a search for the ideal plasmonic material”, *J. Phys.: Cond. Mat.*, Vol. 21, 144211, 2009.
5. A. Boltasseva and H. A. Atwater, “Low-Loss Plasmonic Metamaterials”, *Science*, Vol. 331, 290, 2011.
6. M. A. Noginov, G. Zhu, M. Mayy, B. A. Ritzo, N. Noginova1 and V. A. Podolskiy, “Stimulated Emission of Surface Plasmon Polaritons”, *Phys. Rev. Lett*, Vol. 101, 226806, 2008.
7. E. Plum, V. A. Fedotov, P. Kuo, D. P. Tsai and N. I. Zheludev, “Towards the lasing spaser: controlling metamaterial optical response with semiconductor quantum dots”, *Opt. Express*, Vol. 17, 8548, 2009.
8. S. M. Xiao, V. P. Drachev, A. V. Kildishev, X. J. Ni, U. K. Chettiar, H. K. Yuan and V. M. Shalaev, “Loss-free and active optical negative-index metamaterials”, *Nature*, Vol. 466, 735, 2010.
9. M. Ricci, N. Orloff and S. M. Anlage, “Superconducting Metamaterials”, *Appl. Phys. Lett.*, Vol. 87 , 034102, 2005.