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Achieving hyper-resolution in direct laser writing using epsilon-near-zero meta-materials

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An increasing amount of research is being devoted to improving the spatial resolution of photo-polymerization in direct laser writing, a method used to microfabricate photonic circuits, ordering matrices for nanoemitters, and plasmonic-photonic transistors, just to name a few. Hyperbolic metamaterials and nanocavities enable a variety of uncommon optical effects such as extraordinary transmittance, zero reflectance, giant dephasing, and epsilon-near-zero permittivity.[1] We used a metal/insulator/metal/insulator planar multilayer to upgrade a standard two-photon direct laser writing process to hyper resolution.[2] The improved resolution opens new possibilities in the microfabrication of next-generation 2d/3d nanoscale devices, ordering matrices for nanoparticles, flexible substrate with tunable plasmonic resonance, and in thermoplasmonics[3]. Moreover, a high resolution is crucial for industrial applications in fields such as anti-counterfeiting and flat optics. Having reduced the voxel size by about 89% in height and 50% in width, we fabricated microlabel encoding physical unclonable functions,[2] and apochromatic broadband metalenses with extended focal length and depth of focus, with a numerical aperture of 0.87.[2]

References

1 Lio G.E., Ferraro A., Giocondo M., Caputo R., and De Luca A., Advanced Optical Materials 8 (2020) 2000487.
2 Lio G., Ferraro A., Ritacco T., Aceti D.M., De Luca A., Giocondo M., and Caputo R., Advanced Materials 33 (2021) 2008644.
3 Lio G.E., De Luca A., Umeton C.P., and Caputo R., Journal of Applied Physics 128 (2020) 093107.

Short Bio: Dr. Giuseppe Emanuele Lio received his M.Sc. degree in in Science and Engineering of Innovative and Functional Materials with full marks September 2017 at the Univ. of Calabria. From April to July 2017 he spent a period of internship at the Univ. of Technology of Troyes, France. He awarded the Ph.D in Physics, Chemistry and Material Science and Technology at Univ. of Calabria and the CNR-Nanotec. He published several papers focused on photopolymerization, nano-scale fabrication, numerical simulations, and experimental measurements in optics, photonics and plasmonics. He developed experimental expertises in ellipsometry, micro and nano-fabrication, spectroscopy analysis, and spectrofluorometry. He was invited as Research Scholar in the NanoPlasmLab at the Case Western Reserve Univ. in Cleveland, Ohio, USA. There, he improved his knowledge in gain-materials modeling, and deep machine learning used to design metasurfaces with nano-scale features. Now he is research fellow at CNR-INO and LENS.