Active Plasmonics

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Strong light-matter intercations can be realised in plasmonic nanostructures openning up opportunities to control electromagnetic signals on subwavelength scales. In this talk we will discuss various plasmonic and metamaterial-based approaches for achieving active nanophotonic functionalities. All-optical and electro-optical effects as well polarisation and dispersion management with plasmonic nanostructures and their sensing applications will be overviewed.

Plasmonics makes use of coupling between electromagnetic waves and free-electron excitations at the interface of good conductors. The electromagnetic field enhancement effects associated with surface plasmons and specific to them field confinement result in a strong sensitivity of plasmonic modes to dielectric surroundings, thus facilitating all-optical and electronic control of their propagation [1,2]. These properties are especially suitable for development of active integrated componnets which can be used within purely plasmonic circuits or incorporated into photonic, e.g., Si-based, circuitry to achive desired functionality which is difficult to achive by other means [3]. Going beyond conventional plasmonic materials, such as Au and Ag, new material platfoms based on CMOC compatible metals such as Al and Cu, highly doped semiconductors, transparent conductive oxides and metamaterials have been developed. In particular, by controlling arrangements of plasmonic nanostructures withing metamaterials, complete control over surface plasmonic dispersion and field enhancement can be achieved [4-6]. Combining plasmonic nanostructures with electro-optical materials or using their free-electron nonlinearities, various types modulators and switches can be demosntrted operating at very low powers.

In this paper, we will overview active nanophotonic functionalities based plasmonic and metamaterial waveguides and discuss integrated and free standing componets for signal modulation, and polarisation and dispersion [7-13]. With a strong refctive index sensetivity diue to the field confinement and enhancement, intgrated plasmonic and meamaterial circuitry can also be used for high-performance sensing applications.

References

[1] A. V. Zayats, S. A. Maier, Eds., *Active plasmonics and tuneable plasmonic metamaterials*, Wiley, New York, 2013

[2] A. V. Krasavin, A. V. Zayats, *Active nanophotonic circuitry based on dielectric-loaded plasmonic waveguides: a review*, Adv. Opt. Mat., vol. 3, pp. 1652-1799, 2015.

[3] A. V. Krasavin, A. V. Zayats, *Benchmarking system-level performance of passive and active plasmonic components: integrated circuits approach*, Proc. IEEE, vol. 104, pp. 2338-2348, 2016.

[4] W. Dickson, S. Beckett, Ch. McClatchey, A. Murphy, D. O'Connor, G. A. Wurtz, R. Pollard, A. V. Zayats, *Hyperbolic polaritonic crystals based on nanostructured nanorod metamaterials*, Adv. Mat., vol. 27, pp. 5974-5980, 2015.

[5] N. Vasilantonakis, M. Nasir, W. Dickson, G. A. Wurtz, A. V. Zayats, *Bulk plasmon-polaritons in hyperbolic nanorod metamaterial waveguides*, Laser Phot. Rev., vol. 9, pp. 345-353, 2015.

[6] A. Neira, G. A. Wurtz, A. V. Zayats, *Superluminal and stopped light due to mode coupling in confined hyperbolic metamaterial waveguides*, Sci. Rep., vol. 5, 17678, 2015.

[7] C. P. T. McPolin, J.-S. Bouillard, S. Vilain, A. V. Krasavin, W. Dickson, D. O'Connor, G. A. Wurtz, J. Justice, B. Corbett, and A. V. Zayats, *Integrated plasmonic circuitry on a vertical-cavity surface-emitting semiconductor laser platform*, Nat. Comm., vol. 7, 12409, 2016.

[8] C. McPolin, N. Olivier, J.-S. Bouillard, D. O'Connor, A. V. Krasavin, W. Dickson, G. A. Wurtz, and A. V. Zayats, *Universal switching of plasmonic signals using optical resonator modes*, Light: Sci. Appl., vol. 6, e16237, 2017.

[9] O. Lysenko, M. Bache, N. Olivier, A. V. Zayats, A. Lavrinenko, *Nonlinear dynamics of ultrashort long-range surface plasmon polariton pulses in gold strip waveguides*, ACS Photonics, vol. 3, pp. 2324–2329, 2016.

[10] A. Neira, N. Olivier, M. E. Nasir, W. Dickson, G. A. Wurtz, A. V. Zayats, *Eliminating material constraints for nonlinearity with plasmonic metamaterials*, Nat. Comm. vol. 6, 7757, 2015.

[11] A. D. Neira, G. A. Wurtz, P. Ginzburg, A. V. Zayats, *Ultrafast all-optical modulation with hyperbolic metamaterial integrated in Si photonic circuitry*, Opt. Exp., vol. 22, pp. 10987-10994, 2014.

[12] J.-S. Bouillard, S. Vilain, W. Dickson, G. A. Wurtz, A. V. Zayats, *Broadband and broadangle optical antennas based on plasmonic crystals with linear chirp*, Sci. Rep., vol. 2, 829, 2012.

[13] A. S. Shalin, P. Ginzburg, P. A. Belov, Yu. S. Kivshar, A. V. Zayats, *Nano-opto-mechanical effects in plasmonic waveguides*, Laser Phot. Rev., vol. 8, pp. 131-136, 2014.