Tunable Plasmonic Luminescence in Reconfigurable Metamaterials

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Abstract: We show that new intense luminescence lines associated with transitions from collective plasmonic states below the Fermi level can be artificially created by metamaterial nanostructuring of plasmonic metals and tuned by nanoscale reconfiguration of metamaterial.

We report on the experimental demonstration of a new radiation phenomenon on the nanoscale and its engineering into a reconfigurable metadevice: luminescence emission lines within the Fermi sea can be created by nanopatterning metal surfaces and controlled by external electrical inputs.

Luminescence emission lines are associated with the decay of plasmonic excitation and are spectrally linked to the plasmonic absorption lines. Wavelength, polarization and intensity of metallic luminescence can be flexibly and independently adjusted by tweaking the geometric parameters of the metamaterial design similar to the way nanostructuring helps engineering semiconductor multiple quantum well and quantum dot luminescence.

Borrowing the concept of reconfigurable photonic metamaterials [1], we moreover prove that the wavelength of the emitted light can be tuned through electromechanical reconfiguration of the local density of states (LDOS) in the plasmonic metamaterial by applying an external voltage (Fig1).

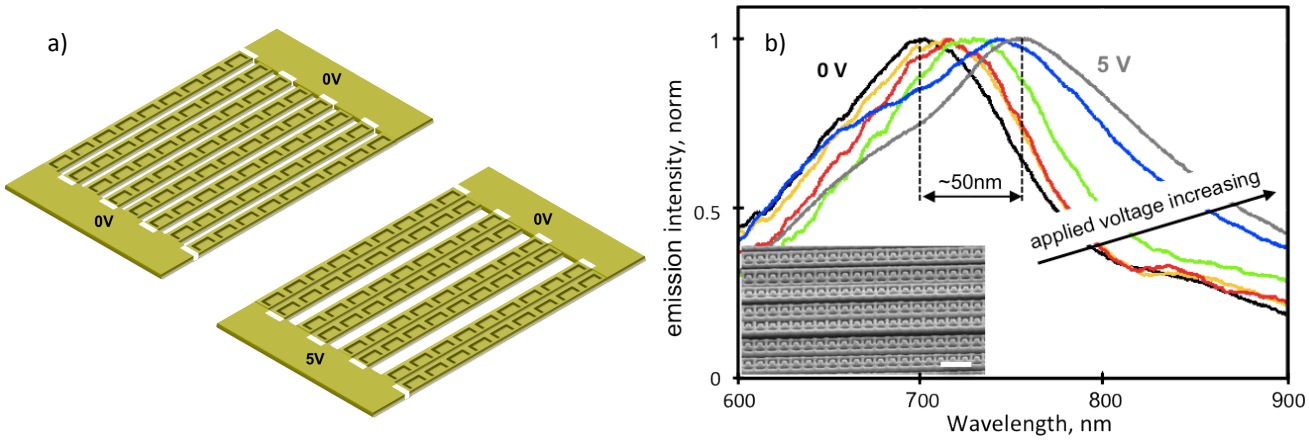

Fig. 1 *a) Metamaterial design onto electrostatically reconfigurable bridges with every second bridge disconnected at the electrode side in alternate fashion; (Top) starting configuration, no voltage applied; (Bottom): when voltage is applied the bridges are mutually attracted in pair thus changing the LDOS across the metamaterial.*
b) Tunable light emission from a metamaterial driven by free-electrons: emission wavelength of the metamaterial can be dinamically tuned applying external electric signals. Inset shows a secondary electron image close-up of the bridges in a reconfigurable metamaterial (scale bar 700nm).

By simply nanostructuring the metamaterial pattern onto flexible bridges (Fig1a and Fig1b instet) the interaction among metamolecules can be dynamically modified thus leading to tuning of the wavelength and intensity of emission.

In summary we introduce a new kind of light emission phenomenon which can underpin a whole new class of light emitting metadevices where the characteristics of the emission can be controlled by design and electrically tuned.

References

[1] J. Ou, E. Plum, N. I. Zheludev *MHz bandwidth electro-optical modulator based on a reconfigurable photonic metamaterial* CLEO:2012, San Jose, United States, 06 - 11 May 2012