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STEFANO PALOMBA 'Kerr Effect in Hybrid Plasmonic Waveguides'

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Seminar, March 6, 2017, 12:00. Seminar Room

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Optical nonlinearities have already enabled a range of capabilities, such as signal switching, de-multiplexing, wavelength conversion, light amplification and supercontinuum generation. Integrating these abilities in an on-chip photonic platform will lead to benefits in terms of cost, footprint, energy consumption and performance. These will in turn help meeting current demands of larger bandwidth, enabling all-optical signal processing vastly overcoming the electronic bottlenecks. The current leading platform for integrated nonlinear optics is silicon-on-insulator (SOI). However, silicon suffers from a fundamental material limit imposed by strong two-photon absorption (TPA) and the diffraction limit. Among complementary and alternative platforms, the hybrid plasmonic platform, has gained attention as it generates strongly compressed fields with moderate losses. The simplest structure of this kind is represented by a nonlinear dielectric material, sandwiched between a metallic layer and a Si nanowire, for which the first experimental evidence of third order nonlinearities we recently reported. Here the plasmonic and photonic modes are combined to generate a hybridized fundamental mode which has been shown to possess a high field confinement, associated with the plasmonic mode, and reduced propagation losses, associated with the photonic mode. The high confinement and modest loss is required for producing strong nonlinearities, which may be further increased through the incorporation of highly nonlinear polymers. Although the geometry with the largest theoretically reported nonlinear parameter is of this type, the origin for such a high nonlinearity remains somewhat unclear. In order to gain more insight we have analyzed the Kerr nonlinear parameter of HPWGs, which quantifies the strength of the nonlinear effect, and its dependence on the energy velocity, effective area and the average nonlinear refractive index, with and without the presence of the nonlinear polymer. In addition, in order to ef?ciently evaluate their Kerr nonlinear performance we propose a simple ?gure of merit (FOM) for Kerr nonlinear effects in plasmonic waveguides, including degenerate four wave mixing (DFWM). The effectiveness of the FOM is veri?ed with an all-plasmonic waveguide and a hybrid-plasmonic waveguide con?guration. Rigorous results show that the length for optimal DFMW ef?ciency is equal to the attenuation length, and that the FOM provides the obtainable upper limits of the DFWM ef?ciency and the nonlinear phase shift. These results provide fundamental theory and useful guidance in exploring plasmonic waveguides for nonlinear optical applications.

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Hosted by Prof. Valerio Pruneri