EFFICIENT ELECTRICAL-PLASMON GENERATION AND MANIPULATION FOR HIGH SPEED NANOELECTRONICS

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To realize small footprint and high speed nanoelectronics, the plasmonics based tunneling electrons have been shown as a potential technology. In general, surface plasmons have been demonstrated that they are able to be directly excited by tunneling electrons in different ways including scanning tunneling microscopes (STMs), metal–insulator–metal junctions using vacuum or metal oxides or molecular tunneling barriers. The direct excitation of plasmons by tunneling electrons is attractive because, on the one hand, there is no background light generated, and on the other hand this approach is feasible to develop fast devices (on the timescale of quantum tunneling) as no slow electron–hole recombination processes are required.

In this talk we will report our recent development of theoretical frameworks to model and simulate the direct excitation of plasmons based on tunneling electrons with respect to different metallic and graphene plasmonic structures. First the directional excitation of electrical-plasmon propagating surface plasmons on a periodic 1D Au cavity by a STM will be addressed [1]. Second thanks to electron tunneling in self-assembled monolayers (SAM), the on-chip molecular electronic plasmon sources consisting of tunnel junction 2nm-layer of SAM sandwiched between two metallic electrodes that excite plasmons will be discussed in detail [2]. Third, by using 2nm-metal oxide layer in MIM junction, we will demonstrate that on-chip electronic-plasmonic transducers can be achieved to efficiently generate, manipulate and transfer plasmons [3]. Last, we will demonstrate that the graphene is potentially a highly efficient material for tunneling excitation of plasmons because of its narrow plasmon linewidths, strong emission, and large tunability in the mid-IR wavelength regime [4].

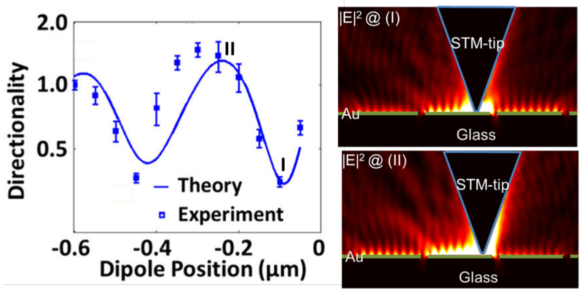

Fig.1 Directional excitation of SPPs on an Au 1D cavity for both FDTD calculation and measurement together with the near-field intensity calculation with respect to two different positions (I) and (II).

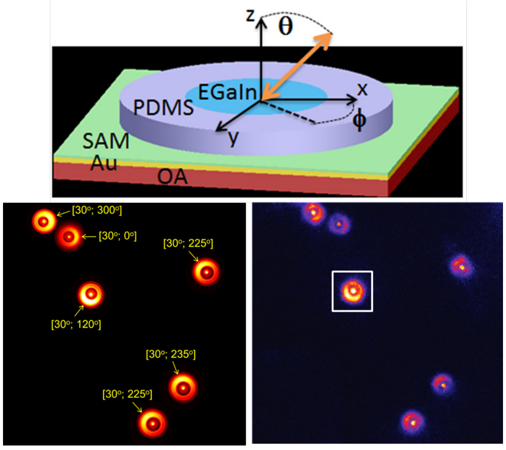

Fig. 2 3D structure of plasmon source with 2nm-molecular tunneling junction (SAM) with schematic of dipole orientation defined by angles θ and ϕ (upper figure). The bottom left and right are the numerical and experimental calculation for plasmon spots in tunnel junction with different polarizations.

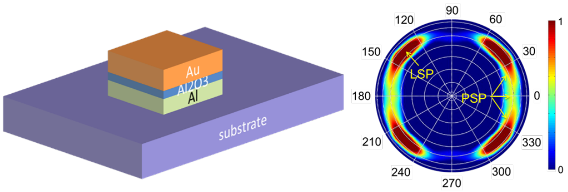

Fig. 3 Schematic of the sub-nm gap plasmon excitation from a MIM tunnel junction (left image).The modeling of back focal plane image for localized surface plasmon and propagating surface plasmon of 2μm^2 square Al/Al2O3/Au MIM junction.

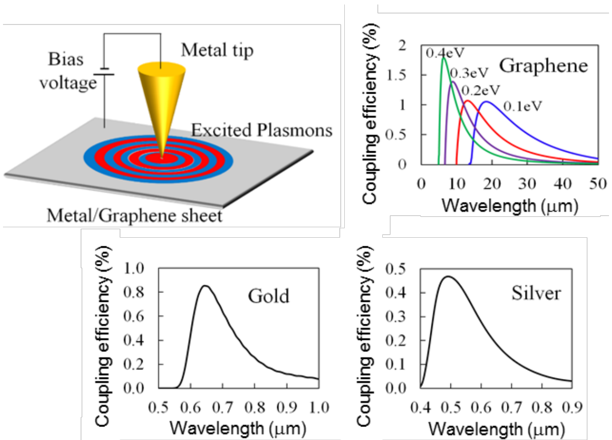

Fig. 4 Schematic of the plasmon excitation from a metal-insulator-metal/graphene tunnel junction and coupling efficiencies of gap plasmons to graphene gold and silver film respectively.

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