J Laser Opt Photonics 2018, Volume 5
DOI: 10.4172/2469-410X-C5-036



# Study of plasmonics and phononics in nanohybrids made of graphene and polar crystals and their applications to nanoswitches and nanosensors

**Mahi R Singh**
The University of Western Ontario, Canada

There is a considerable interest in developing nanoscale plasmonic devices by combining graphene with quantum emitters (QEs) and metallic nanoparticles into hybrid nanostructures [1-6]. Graphene was invented theoretically by Wallace in 1947 [1] and he found that graphene is a gapless material. Later, Wallace and I found more gapless materials such as Cd3AS2, HgTe which have direct band gaps [2]. We showed that the optical energy absorption/emission is stronger in the direct bandgap materials than indirect band materials. Most the research on nanoplasmonics has focused mainly on noble metals. The problem with the noble metals is that they are hardly tunable and exhibit large Ohmic losses which limit their applicability to plasmonic and optoelectronic devices. On the other hand, graphene plasmons provide an attractive alternative to noble metal plasmons. It is because they exhibit much tighter confinement, small Ohmic losses and have relatively long propagation distances. The SPPs in graphene can also be tunable via electrostatic gating technique. Graphene has also emerged as a very promising candidate for THz to visible frequency applications since its plasmonic resonance frequency lies in this range. Here we investigate the effect of phonon-plasmon and surface plasmon polaritons on photoluminescence in graphene deposited on polar crystals. Other zero-band-gap nanostructures will be also included in the present study. Using the second quantized formulation for SPPs and PPs interaction and density matrix method we have calculated photoluminescence of the quantum emitters. It is found that when the exciton energy of the quantum emitter is in resonant with the SPP and PPP energies the absorption and photoluminescence in the quantum emitter are enhanced in the terahertz range. The enhancement is due to the transfer of SPP and PPP energies from the graphene flake to the quantum emitter. We have also compared our theory with photoluminescence experiments of ZnO-MGF hybrid system deposited on $SiO_2$ polar crystals and a good agreement between theory and experiments has been found. The present theory is also able to explain the change in enhancement due to $SiO_2$ spacer thickness in this hybrid system. The energy transfer from the graphene to the quantum emitter can be controlled by applying external pump lasers or stress and strain fields. This means that the energy transfer from the QDs to the graphene can be switched ON and OFF by external ultrafast laser. These are interesting findings and they can be used to fabricate switches and sensors.

msingh@uwo.ca