Various approaches to loss mitigation in Nanoplasmonics and their limitations.

Jacob B Khurgin
Johns Hopkins University

Recent years have seen staggering growth of interest in using nanostructured metals in optical range with the goal of enhancing linear and nonlinear optical properties or even engineering entirely novel optical materials unknown in Nature. After the initial heady years of excitement the community is recognizing that loss in the metal is an important factor that might impede practical application of plasmonic devices, be it in signal processing, sensing, imaging or more esoteric applications like cloaking. Attempts are being made to “design away” the loss, compensate it by gain, or find new lossless materials. In this talk we examine these concepts one by one and find that they all have their limitations. First we demonstrate that in truly sub-wavelength in all three dimensions metal structures the loss is inherent and cannot be engineered away by clever changes in shape for as long as one operate in visible and IR region of the spectrum, while in THz frequency this approach actually works and explain the reasons behind it. We then consider the idea of compensating loss using semiconductor gain medium and demonstrate that required gain is difficult to achieve and maintain due to increase in recombination rates caused by Purcell’s effect. We also consider a fresh idea for loss reduction by using plasmonic structures combining metals with strongly dispersive dielectrics (as in slow light media) to store the energy in atomic polarization rather than in kinetic energy of electrons and thus achieve orders of magnitude reduction of loss at the cost of reduction in field enhancement. After that we consider the physics of losses in metals at optical frequencies and show that the nature of these losses is quite different from the losses in RF domain. We then show that negative dielectric constant at optical frequencies does not have to inevitably lead to large absorption, and with guarded optimism point to the tentative way in which new materials with negative dielectric constant and very low loss might be synthesized.