Semiconductor Plasmonic Nanolasers

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Metal-semiconductor composite nanostructures provide a unique material choice for many nanophotonic applications from active metamaterials to truly nanoscale lasers, or SPASERs. In a MS structure, surface plasmons in the metal provide a mechanism for wavelength compression to nanoscale [1-3], while semiconductor provides necessary gain to compensate metal loss or exceed the threshold gain. In this talk, I will first discuss basic physical principles of a plasmonic laser and the possibility of an overall modal gain near surface plasmon resonance where metal loss is maximal [1-3]. We will show that the nontrivial behavior of surface plasmons lead to a giant modal gain in a metal-semiconductor waveguide that is 1000 times of the material gain in the semiconductor [2]. This unusually large gain is also manifested in the confinement factor [3-4] which can be as large as 100, 000, in contrast to a value of smaller than unity in the case of a conventional semiconductor laser. As an example of such semiconductor plasmonic nanolasers, I will then present our recent experimental demonstration [5] of the first truly sub-wavelength laser under electrical injection. The semiconductor-metal core-shell waveguide has a core width of 90 nm for the wavelength around 1.5 microns. The total optical thickness of the core including the dielectric insolating layer is roughly 50% of the half-wavelength in vacuum, representing the first nanolaser significantly smaller than the diffraction limit.

References

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