Surface Plasmon Enabled Nanocavity Sub-Wavelength Injection Laser

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Scaling down the size of photonic devices has been extensively researched in the past years. However, lasers operating continuously at room temperature and with overall dimension breaking the limit of emitting wavelength have not been demonstrated to date. Our project seeks to develop a sub-wavelength nanocavity laser by using the new concept of gain assisted surface plasmon polariton (SPS) enabled whispering gallery mode (WGM). Currently, the smallest lasers demonstrated utilize WGM microdisk cavities. Microdisk cavities rely on air cladding for transverse mode confinement. In our proposed structure, the transverse confinement is provided by SPP supported at metal-semiconductor interface instead of air cladding. Capping microdisk with metal layer also improves the thermal dissipation. Meanwhile, SPP provides a larger, effective, refractive index which helps to reduce radiation loss in the nanocavity and therefore increase Q factor. By improving thermal dissipation and increasing Q, we can further scale down the size of laser into sub-wavelength region. In order to understand the behaviors of SPP enabled WGM and design the detailed structure of the nanocavity laser, we use a finite difference time domain (FDTD) method for simulation. For gain assisted SPP propagation, we have obtained simulation results of transverse field profile, propagation length, and effective wavelength from FDTD which agree with the analytical calculation. Simulation allows us to analyze the resonance behaviors and mode patterns of WGM supported by conventional microdisk. These initial results show that FDTD can help us to study the gain assisted SPP enabled WGM supported by metal capped microdisk cavity. Likewise, the resonance wavelength, Q factor, transverse and in-plane mode patterns, and threshold semiconductor gain for lasing should all be predicted in order to optimize the design and the fabrication of our proposed nanocavity laser. This project is supported by the Defense Advanced Research Projects Agency under award number W911NF-07-1-0313.