Surface plasmon distributed feedback lasers
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Distributed feedback (DFB) lasers are compact optical sources used in optical integrated circuits, providing a highly coherent (single-mode) output. These lasers are normally realized in semiconductor quantum well structures using dielectric waveguides. Surface plasmon waveguides are interesting alternatives to dielectric waveguides, enabling different device architectures and functions, and offering greater confinement (with higher attenuation). Loss compensation, amplification and lasing with surface plasmons have been demonstrated in various guiding structures; indeed, significant progress has been achieved in this area within a very short timespan.1 Surface plasmon DFB lasers have been proposed as sources to produce a high-quality emission.2 Here we describe structures realized according to this concept and present first experimental results of lasing.

Our DFB lasers, sketched in Fig. 1, consist of a 20 nm thick Ag stripe on a thick SiO2 layer, covered with 450 nm of IR-140 doped PMMA as the active medium. The Ag stripe is stepped in width (1 to 0.5 μm) in a pitch of Λ ~ 300 nm forming a 1st order Bragg grating with a center wavelength of λB ~ 880 nm, corresponding to the peak emission wavelength of IR-140 dye molecules. Figs. 2 show surface plasmon mode field distributions computed at λ0 = 880 nm.

Fig. 2. Computed surface plasmon mode field distribution for 20 nm thick, 0.5 (left) and 1 μm (right) wide Ag stripes, on SiO2, covered with PMMA.

The lasers were pumped optically from the top using 10 ns laser pulses at 810 nm with maximum peak energy density of ~40 mJ/cm2. Single mode lasing near 880 nm was observed for various DFB laser lengths and pump intensities. A kink in light-light curves was observed along with extremely narrow emission spectra. The threshold for lasing was ~ 7 mJ/cm2. Fig. 3 shows a lasing mode output captured using an infrared camera.

Fig. 3. Measured mode output from a surface plasmon DFB laser, captured using an infrared camera.

References:

Fig. 1. Sketch of a plasmonic DFB laser comprising a metal stripe step-in-width Bragg grating on a SiO2 layer covered with a layer of IR-140 doped PMMA as the optical gain medium. The structure is pumped form the top and the emission is collected from a cleaved facet.