Plasmonic-Enabled Distributed Bragg Reflector Design for Mid-infrared

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Mid-infrared spectral range emitters find a wide array of applications in imaging, free-space communication, and gas sensing. Among the most popular light sources in this spectrum range are diode lasers [1] and quantum cascade lasers employing intersubband [2] or interband transitions [3]. Distributed Bragg Reflectors (DBRs) serve as mirrors or filters in optoelectronic devices, regulating the reflectivity and transmission of light, thereby enhancing overall device performance. Furthermore, DBRs enable the creation of vertical cavities, facilitating surface emission. Vertical cavity structures offer numerous advantages over conventional edge-emitting sources, including high-quality beam output and the ability to test devices on wafers during production.

To achieve high light reflectance, DBRs are constructed using multiple quarter-wavelength layers of alternating high- and low-refractive-index materials, resulting in periodic variations in refractive index. This creates an interface and conduction band offset between the layers, inhibiting current flow and impeding heat transport within devices. Additionally, the semiconductor-based DBR growth process is particularly challenging, especially for the mid-infrared spectral range, due to the significant thickness of quarter-wavelength layers and the mismatch of lattice constants between layers.

In our study, we present experimental demonstrations of plasmon-enhanced InP-based DBRs. In this approach, refractive index contrast between layers is achieved solely through variation in doping levels (undoped InP/n++InP:Si). The presence of free carriers within the structure leads to an increase in the imaginary part and a reduction of the real part of the refractive index. This method eliminates problematic interfaces between layers and greatly facilitates the growth process. Fourier transform infrared spectroscopy was utilized for reflectivity measurements of DBRs, demonstrating values above 90% for several structures designed for different wavelengths.

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