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Plasmonic Laser Using InGaN/GaN Nanorods with Different Shapes

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Extended Abstract

Stimulated emission light in photonic devices on nano-scales is a challenging step to meet the requirements for optoelectronic integrations.[1] In the past decade, tremendous achievements in the fabrication of semiconductor lasers based on photonic crystals, microdisks, ring cavities and the Fabry–Pérot (F-P) cavity have been achieved. However, their size has reached a bottleneck because of the diffraction limit of light when the dielectric medium approach the value of wavelength ($\lambda/2n$).[2-4] One of the most promising approaches for realizing a sub-wavelength nanosized laser with a low threshold relies on the principle of the surface plasmon amplification of stimulated emission of radiation (SPASER).[5-7] In this study, Ⅲ-Nitride-based plasmonic nanolaser with hybrid metal-oxide-semiconductor (MOS) structures is designed based on the principle of surface plasmon amplification by the stimulated emission of radiation (SPASER).[7-9] Through a finite-difference time-domain (FDTD) simulations and eigenmode (MODE) simulations, triangular, hexagonal, cylinder and elliptical nanorods structures are simulated and analysed. The relationship between the geometry of the NRs and the plasmonic/photonic lasing modes was discussed. Finally, plasmonic nanolaser is fabricated by nanoimprint lithography and microfabrication. The photoluminescence (PL) spectra of the designed structure are recorded as a function of the optical pumping power density in a micro-PL system excited by a 325-nm He-Cd laser. The fabricated nanolasers are able to demonstrate lasing behaviour with an optical pumping power density as low as 0.3 kW/cm^2 at room temperature and a quality Q~factor of up to about 120. The low lasing threshold is attributed to the SPP coupling-induced strong electric field confinement in the MOS structures and optimization of MOS structure. In accordance with the theoretical and experimental results, the size and shape of the nanorod (NR) are key for the lasing modes and reduction in loss. We believe geometrical and technical optimization can further enhance the lasing properties. These achievements should extend the size range of lasers to the subwavelength scale and allow hybridization of their lasing modes, which could be vital for information processing applications.

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