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Advances of plasmonic nanolasers

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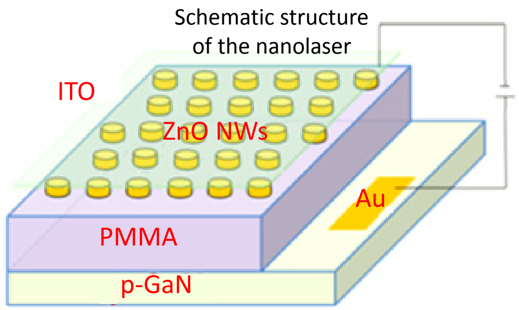

Principle diagram of the arrayed nanowires palsmonic laser.

Abstract: Semiconductor lasers are widely used for applications in biology, information storage, photonics and medical therapeutics. Along with the emerging area of nano-optics and nanophotonics, more compact lasers with size miniaturization attract significant interest. Last decades, many researchers tried to investigate the miniaturization technology of photon laser. The aiming is to obtain higher density devices integrated on smaller semiconductor chip. As the cavity size is reduced with respect to the emission wavelength, interesting physical effects, unique to electromagnetic cavities, arise. So, to scale down the semiconductor lasers in all three dimensions plays an important role in the developing of low-dimension, low-threshold, and ultrafast coherent light sources, as well as integrated nano-optoelectronic and plasmonic circuits. For this purpose, the nanolasers and smaller plasmonic nanolasers are developed during the last years. However, for the conventional semiconductor laser using dielectric cavity oscillator (photon cavity), the noticeable obstacle from diffraction limit confines the feature sizes of the nanodevices all the time, and makes them unable to get down to half wavelength level. These years, the invention of plasmonic nanolaser, where the light is enhanced by stimulated emission based on surface plasmon, can break through the bottleneck of optical diffraction limit and give out light with subwavelength scale. In this review, above all, the principle of cavity used in laser and the theory of the modal gain are illustrated generally. Besides, the important properties and the technical characters of the plasmonic nanolasers are introduced briefly. Then, the overall research progress of the plasmonic nanolasers are presented, which is explained by some typical plasmonic nanolasers, such as, surface palsmon-optical mode hybrid nanolaser, metal-dielectric heterogenic cavity plasmonic nanolaser, metal-insulator-semiconductor (MIS) subwavelength plasmonic nanolaser are introduced by turn. In addition, an updated overview of the latest developments, particularly in plasmonic nanolasers using the MIS configuration and other related metal-cladded semiconductor microlasers is presented. In particular, it has been experimentally demonstrated that the use of plasmonic cavities based on MIS nanostructures can indeed break the diffraction limit in all three dimensions. The research group proposed a new plasmonic nanolaser based on semiconductor nanowire/air spacer/metal film composited structure. This structure can get modes coupling between the surface plasmon on the metal and the high gain nanowire, which makes the enhancement effect increased obviously. It is shown that the structure can confine the output optical field to subwavength scale, and keep low transmission loss and high ability of the confinement. In this review, the experimental results are presented in detail. In the end, we give a contrast about the parameters and results for the new achievement in palsmonic nanolasers research area. Based on the recent development of the plasmonic nanolaser, we conclude about the developing trend. We also give some perspectives on the challenges and development trend for the plasmonic nanolasers. This review can provide useful guide for the research of plasmonic nanolasers.

Keywords: plasmonic nanolaser; surface plasmon; micro/nanofabrication

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See page 140 for full paper.