Nanooptics and nanophotonics

Plasmonic nanolaser with nonlinear absorption gas nanocavity

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Coherent light and surface plasmon generation on nanoscale has recently attracted significant attention due to numerous potential applications in the fields ranging from biosensing to optical interconnects. The physical dimensions of laser are defined by its cavity which generates optical feedback based on constructive interference of propagating waves. Since the interference requires phase accumulation of at least 2π, the resonator dimensions cannot be much smaller than half wavelength in each direction and, in fact, are limited by the classical diffraction. As well known the smallest lasers approaching this limit are Vertical-Cavity Surface-Emitting Lasers (VCSELs).

Conceptually different approaches are required for creation of sub-diffraction coherent light generating systems. One of the promising solutions is based on incorporation of nanometric structures made of noble metals supporting plasmonic excitations. Such structures can confine light far-beyond the natural limit of diffraction by coupling it into coherent oscillations of free conduction band electrons near metal surfaces. The plasmonic effect can confined optical mode in one or two dimensions, while the facet reflections in third dimension can be used to generate sufficient feedback for lasing.

Ideologically new approach to laser resonators was proposed by M.Stockman et al. US Patent, 7569188, August 4, 2009. It was suggested to replace the interference phenomena by the near-field feedback and in such way it was introduced the concept of SPASER as a coherent source of plasmonic excitations. In a case of efficient coupling of localized surface plasmons (LSPs) in far-field photons, the SPASER can be considered as a nanolaser. This system was successfully demonstrated, employing a core metal nanoparticle and surrounding active dyes.

Our report main new idea is to investigate the opportunity of obtaining coherent radiation from nanometric laser with nonlinear atomic or molecular absorption. We propose some real system and give needed estimations for lasing at sufficiently narrow and frequency stable lines of rear-earth atom in solid and molecular gas in nanocavities. We used the anomalous enhancement of radiation probabilities of molecules near the nanopores as main way to put the lasing at narrow inverted Lamb-dip.