Directivity of sub-wavelength wire lasers

Ekaterina E. Orlova

***Abstract*—Theoretical model has been developed for the emission from long lasers with sub-wavelength transverse dimensions (wire lasers). Based on this model the far field pattern of THz quantum cascade lasers is explained. Concentration of the radiation into a narrow beam is predicted for the modes with the phase velocity close to that of light in the air (synchronized modes). The ways of control of the phase velocity and the properties of the synchronized modes are discussed.**

***Index Terms*—Laser radiation effects**

DEVELOPMENT of nano-technologies enables reduction of the size of the optical devices down to sub-wavelength dimensions. Sub-wavelength size of an aperture is known to cause a dramatic increase of the beam divergence due to diffraction, which hinders effective coupling of such devices. The problem of directivity is especially important for the sources of terahertz radiation due to relatively big wavelengths. Recent investigations of the beam properties of terahertz cascade lasers with sub-wavelength cross section [1,2] has revealed that the structure of the far field of such lasers is controlled by the interference of radiation from the longitudinal distribution of emission sources within the laser. Theoretical model has been developed for the emission structure of the lasers with sub-wavelength cross sections (wire lasers) [1], showing that the far field of such lasers is analogous to that of antennas of traveling wave. This model predicts that radiation of sub-wavelength wire lasers can be concentrated into a narrow beam with a divergence determined by the ratio of the wavelength to the length of the laser. High directivity is possible for the laser modes with the phase velocity close to that of light in the air (synchronized modes). However the difference of these phase velocities enters linearly in the exponential factor of the transverse decay of the modes. The slower decay of the field outside the active region may lead to a relatively low effective gain of the synchronized laser modes. The ways to control the longitudinal phase velocity and the ways to increase the confinement of the synchronized modes will be discussed.

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E. E. Orlova is with the Institute for Physics of Microstructures, Russian Academy of Sciences, N. Novgorod GSP-105, 603950 Russia (phone: 7831-238-5037; fax: 7831-238-5553; e-mail: orlova@ipm.sci-nnov).

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