Tunable CW and pulsed THz lasing of strained p-Ge

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Hot-hole semiconductor lasers are very attractive for applications as tunable THz sources. Several mechanisms are known for the formation of population inversion of holes in a semiconductor in the strong electric and magnetic fields [1]. All of them are based on the so-called streaming motion of holes which takes place in moderately doped semiconductors at low temperatures. At sufficiently high applied electric field, the carriers accelerate up to optical phonon energy, emit an optical phonon and return to the low energy state. As a result of such a shuttle motion, the distribution function of the carriers becomes stretched out along the field direction. If a magnetic field is applied, the carrier trajectories in the streaming regime change their character, thus giving rise to the population inversion.

An alternative possibility for stimulated THz emission with no magnetic field applied was demonstrated with p-doped Ge under uniaxial stress [2]. In this case, the optical transitions between resonant and localized acceptor states are the cause of the emission. In strained p-Ge, acceptor levels are split and at sufficiently large stress, the level split off from the ground state enters the continuum of the valence band and becomes resonant. In external electric field, the localized states are depopulated due to impact ionization, while the resonant states are filled due to hot holes. As a result, the intracenter population inversion is formed [3].

Lasing was observed from Ga doped Ge samples with Ga concentration varied from $3x10^{13}$ cm^{-3} to 10^{14} cm^{-3}. Crystals of the size 1*1*10 mm^3 were cut in [111] or [001] crystallographic directions; uniaxial stress and electric field were applied parallel to the long axis of the sample. The parallel faces of the crystal formed the optical resonator. The emission frequencies can be tuned by pressure 4 to 12 kbar in the range between 2.5 and 10 THz. The maximum emitted power was at least several tens of μW in cw regime and several mW in pulse regime. The lasing was observed at temperatures below 20 K.

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