Carrier dynamics and stimulated radiative terahertz transitions between Landau levels in cascade GaAs/AlGaAs quantum well structures

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Abstract— **A resonant tunneling periodic quantum well structure with asymmetric double quantum well period is proposed to achieve a population inversion and a frequency-tunable THz emission on intersubband transitions between Landau levels in a tilted magnetic field.**

I. INTRODUCTION

RECENTLY we proposed a mechanism of a stimulated emission of coherent terahertz radiation on intersubband transitions between Landau levels in periodic resonant tunneling quantum well structures under a resonant tunneling pumping of upper subband[1,2]. A considerable population inversion between ground (0th) Landau level (LL) in upper subband and first excited (1st) LL in lowest subband was shown to be achieved in a rather wide continuous range of the magnetic field if the intersubband spacing $\Delta\varepsilon_{1\nu}$ is lower than an optical phonon energy. The frequency of the inverted transition is determined by the relation

$$\hbar\omega = \Delta\varepsilon_{1\nu} - \hbar\omega_c, \qquad (1)$$

where ω_c is the cyclotron frequency. The main scattering mechanism determining the population of the inverted levels was shown to be the electron-electron (e-e) scattering [2].

The asymmetric double well periodic structures attracted our attention since being placed in tilted magnetic field they provide possibility to lift the selection rule forbidding the inter-LL transitions of interest and to achieve significant values of the corresponding dipole matrix element [3].

Here the effect of the asymmetry in spatial location of the subband wave functions on the intersubband scattering times and population inversion was studied by a direct calculation of scattering probabilities in the periodic structure of the period consisting of two strongly coupled quantum wells placed to the magnetic field tilted with respect to structure layers.

II. RESULTS

It was shown that the relative shift of different subband wave functions caused by the structure asymmetry leads to a considerable increase of intersubband scattering time (see Fig 1) as compared with single symmetric quantum well while the intensity of intrasubband scattering remains practically the same. So the relative shift of subband wave functions in double quantum well structure decreases significantly the probability of intersubband e-e scattering from upper lasing level (2,0), resulting in significant improvement of the terahertz emission efficiency can be achieved as due to the considerable values of inter-Landau level dipole matrix element as due to the increase of the population inversion [3].

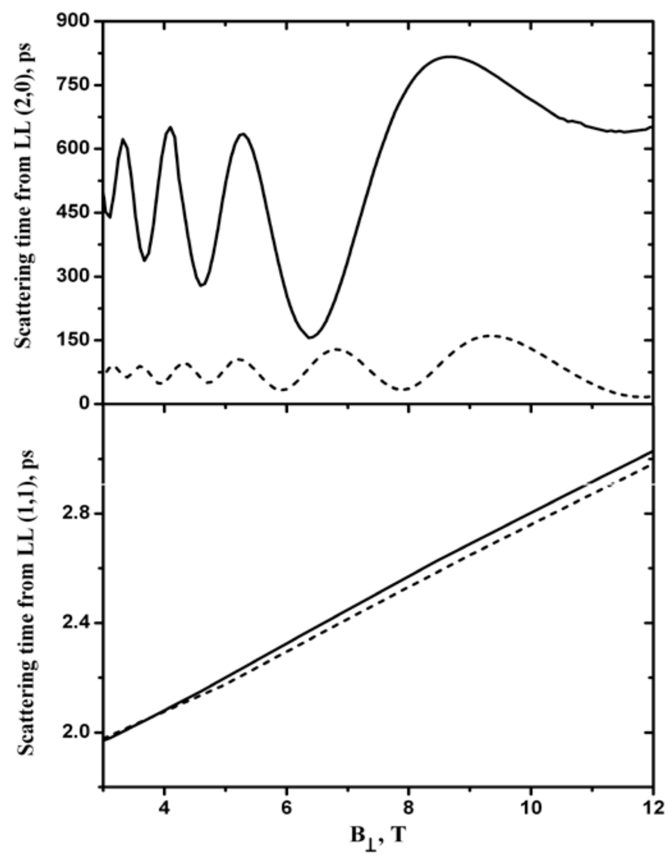

Fig. 1. (**a**) -The calculated electron-electron scattering time from the upper (2,0) Landau level as a function of magnetic field component $B_\perp$ perpendicular to the structure layers in double (solid line) and in a single (dashed line) quantum wells.
(b) – similar dependencies of the scattering times from lower (1,1) Landau level. $N_{(2,0)} = N_{(1,1)} = 10^{10}$ cm^{-2}, magnetic field tilting angle $\theta = 45^0$.

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