Hybrid intersubband surface plasmon polaritons

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When an *n*-doped multiple quantum well (MQW) slab is embedded into a dielectric microcavity (MC) the resonant coupling between the ground cavity mode (TM_1) and the intersubband excitation (with the frequency ω_{IT}) can be achieved [1]. Consequently, the formation of the intersubband cavity polariton branches is possible.

In many systems studied experimentally the *n*-doped dielectric layers also play the role of microcavity mirrors [2, 3]. The presence of free carriers in the mirror material leads to the reduction of the mirror dielectric function. Because of that, the plasmonic mirrors can be substantially thinner compared to purely dielectric mirrors. However, the presence of the free electrons in the mirror material leads to the formation of the additional – the surface plasmon polariton modes, i.e. TM_{-1} and TM_0.modes. The above mentioned modes are located below the ground photonic mode or, more precisely, below the plasma frequency (ω_p) of the mirrors [4,5,6]. When (like in the systems studied in Refs. [2, 3]) the above mentioned frequency is substantially smaller than ω_{IT}, the coupling of the intersubband excitation with the surface plasmon polariton modes can be neglected [5]. It is obvious that the system can be also designed so as to achieve the resonant coupling between the surface plasmon polariton modes and the intersubband excitation. In such systems the formation of the hybrid intersubband surface plasmon polariton branches should be observed. The inspection of the theoretical results reported in Ref. [6] (where the formation of the hybrid exciton surface plasmon polariton is discussed) suggests that the intersubband surface plasmon polariton modes can have interesting new properties, not observed in the MQW-MC systems with the dielectric type mirrors. It is mainly connected with the fact that the behavior of TM_0 mode depends strongly on the cavity thickness. For different parameters it can have either positive or negative dispersion at small k (= in plane wave vector) [6].

In this paper we discuss the resonant coupling between the surface plasmon polariton modes and the intersubband excitation in the uniform (model I) and strongly nonuniform (model II) systems. Model I is composed of the MQW slab bounded by plasmonic mirrors. Model II corresponds to the case when only half of the space between the mirrors is occupied by the MQW slab. The above mentioned slab is modeled (employing the effective medium approximation [5]) by uniaxial uniform medium. For simplicity, the intrasubband excitation, the dissipation and the dielectric mismatch are neglected. The dispersion characteristics are interpreted employing the multiple coupled harmonic-oscillator model [5]. The effects connected with the strong penetration of the surface plasmon polariton mode functions into the mirrors are taken into account. The role of the surface mode coupling (mediated by intersubband excitation [5]) is also considered.

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