Observation of emission decay from GaAs based 2D hole/post array structures

Masashi Nakao, Mitsuru Naganuma* and Masayuki Izutsu**
NTT Photonics Labs., 3-1 Morinosato-Wakamiya, Atsugi, 243-0198 Kanagawa, Japan
**Teikyo Univ. Science & Technol., 2525 Yatsuzawa, Uenohara, 409-0193 Yamanashi, Japan*
***Communications Research Lab., 4-2-1 Nukui-Kitamachi, Koganei, 184-8795 Tokyo, Japan*
E-mail: mnakao@aecl.ntt.co.jp

We have measured emission decays from 2 dimensional (2D) GaAs/AlGaAs multi-layered post/hole array structures using decay measurement system by femt-second laser excitation. We have observed the fast emission decays of the 2D structures in the diagonal direction and the relatively slow decays in the lateral direction and have suggested applicaton to high-Q microcavity lasers.

The 2D periodic structure has been attracted as a new material for the microsize photonic functional devices using its property of photonic band gap (PBG) material. We have reported the fabrication process of semiconductor based 2D periodic structures and their PBG properties [1-3]. Some application trials to PBG laser have been recently reported [4, 5].

2-dimensional semiconductor hole and post arrays were successfully fabricated by a dry etching technique, using an MOVPE-grown GaAs/AlGaAs (DBR layer) and a highly ordered alumina prepared by anodic oxidation as a starting structure. The period of the triangularly aligned hole and post arrays is 300 nm and the radius is around 100 nm for both. The decay measurements have been performed using excitation of a Ti-saphire laser (emission wavelength is 810 nm, the pulse width is ca. 770 fs and is mode-rocked at 80 MHz) pumped by an Ar ion laser (ca. 12 W of output power) and using detection of a streak camera with a 2 ps time resolution.

The results of decay measurements are summarized in Figs. 1 and 2 for the post and hole array, where SEM pictures are also shown in the inset. The excitation laser pulse has a small line width of several pico-seconds as shown in both Figs. The decay time of the photoluminescence from the DBR layer, which has no periodic structure, is several hundred pico-seconds. On the other hand, the decay times from post and hole array structure in the diagonal direction (see the drawings in Figs.) become smaller than that of the DBR layer . The former decay is a little faster than the latter. This reduction of decay time due to formation of the periodic structure may come from dry etching damage, and has reported for the first time for these structures. We have observed the decay feature from the lateral direction in order to clarify the cavity effect of the 2D periodic structures. The emission intensities in the lateral direction become very weak as shown in Figs., and the decay time become much longer as nano-second order. This long decay may cause of cavity effect of PBG of the 2D-periodic structures. The calculated PBG region is around 800-1300 nm for 2D hole array for H-polarization and 850-1100 nm for 2D post array for E-polarization. This shows the possibility of high-Q microcavity for laser in the optional wave length range, because we can determined the position of PBG arbitrarily by changing the periodicity or the radius of the starting hole array structure.

This is first report which has shown decay curves from 2D periodic structure and first observation of the change of the spontaneous emission decay due to PBG-type 2D reflector.

References:
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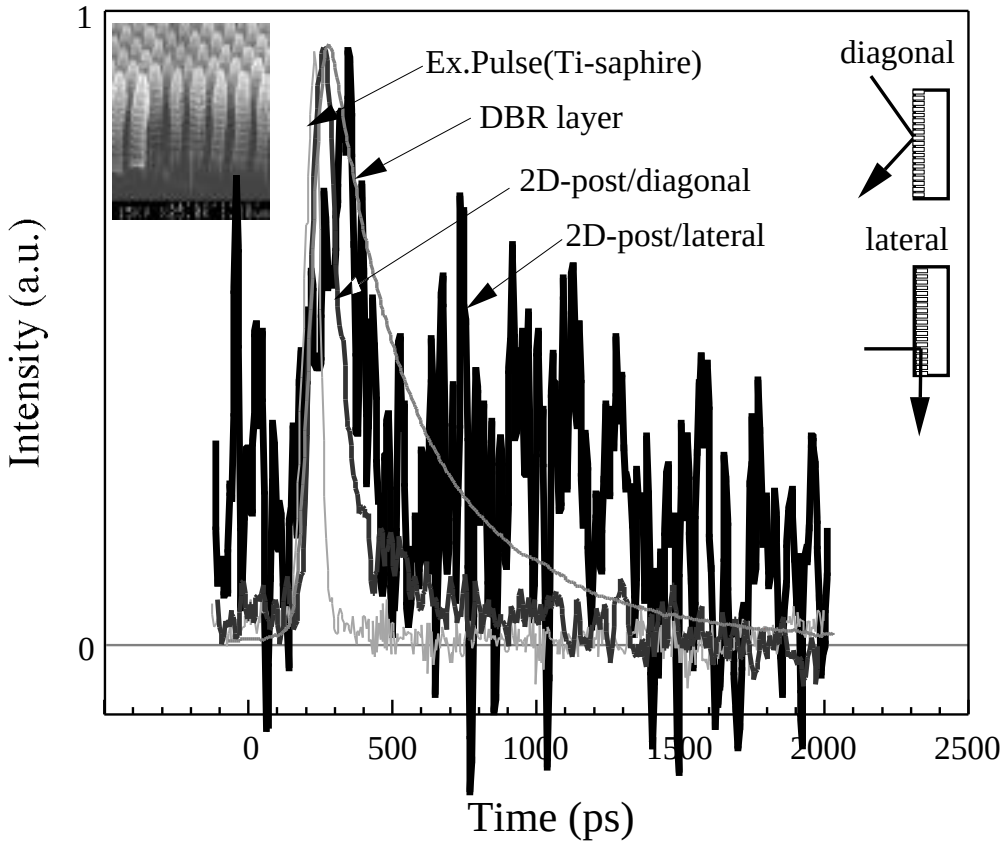

Fig. 1 Emisson decay curves in the case of 2D post-array.

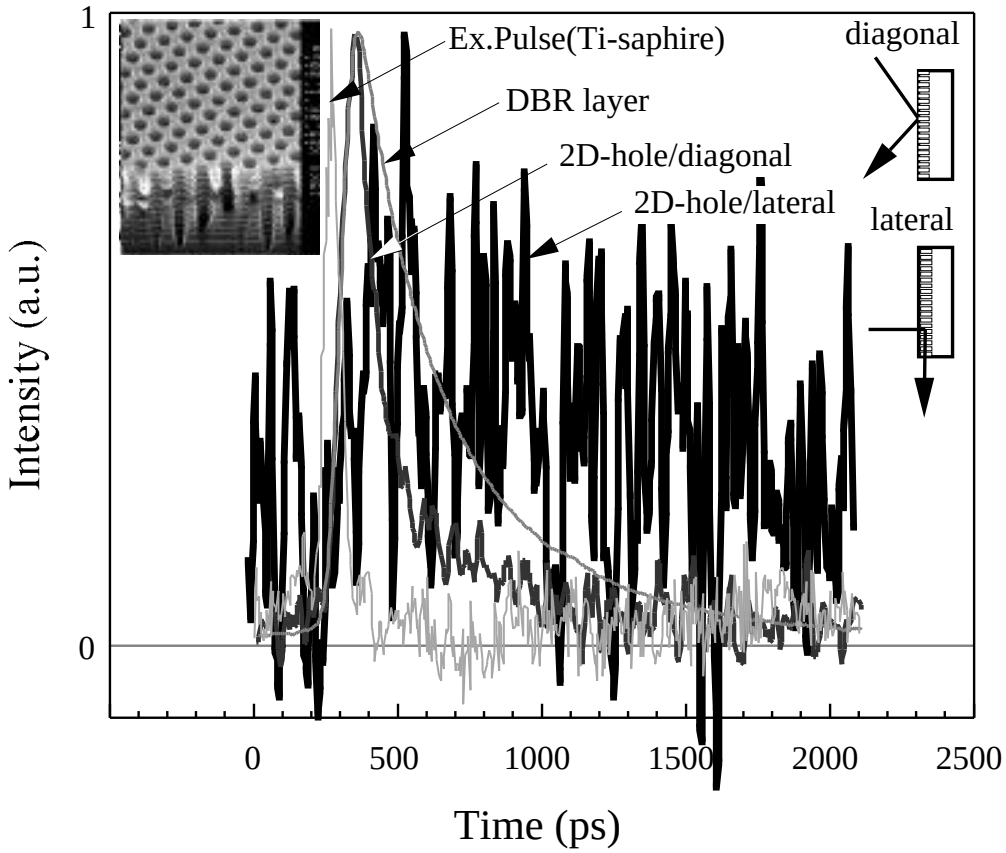

Fig. 2 Emisson decay curves in the case of 2D hole-array.