スピン偏極電子源における量子効率向上ための解析

Analysis of quantum efficiency improvement in spin-polarized photocathode

°金 秀光 [1]、大木 俊介 [2]、石川 友樹 [2]、竹内 淳 [2]、本田洋介 [1]、
(1. 高エネルギー加速器研究機構、2. 早大先進理工)
°X.G. Jin[1], S. Ohki[2], T. Ishikawa[2], A. Tackeuchi[2], Y. Honda[1],
(1. KEK, 2. Waseda Univ.)
E-mail: jinxg@kek.post.jp

Highly spin-polarized electron sources are intensively developed for applications in high energy physics and studies of thin film and surface magnetism [1]. Quantum efficiency (QE), which is defined as a ratio of the number of photo-emitted electrons to the number of incident photons, is important performance to generate high current. Recently, we have successfully developed GaAs/GaAsP strain-compensated superlattices (SL) [2, 3]. Compared with the conventional GaAs/GaAsP strained SL, the strain-compensated SL has no critical thickness limitation, and thus the SL thickness could increase with high crystal quality. In the thicker samples, the absorption of pump laser light increases, so higher QE is expected. In this study, we report the change of the QE with increasing SL thickness.

SL samples were prepared using a low-pressure MOVPE system. Following the growth of a 500 nm-thick $Al_{0.1}Ga_{0.9}As_{0.81}P_{0.19}$ buffer layer on a Zn-doped and (001) GaP substrate, 12~90-pair GaAs 4 nm/$GaAs_{0.62}P_{0.38}$ 4 nm strain-compensated SL were grown.

Figure 1 shows the dependence of the QE on the SL thickness. The QE showed obvious saturation from 192 nm thickness (24-pair) and the QE values were kept almost same value from 288 nm (36-pair). The calculated absorption increases linearly with SL thickness and QE shows larger separation from absorption curve in the thicker samples. The separation means that the more photo-excited electrons eliminated in the thicker samples.

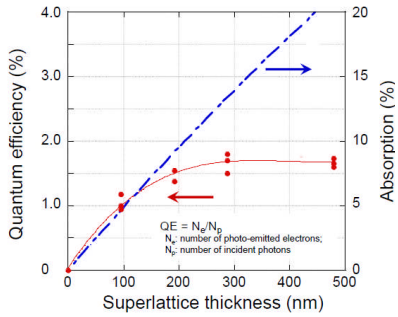

Fig.1 QE change with SL thickness.

A time-resolved photoluminescence measurement revealed that the carrier life time in the 24-pair GaAs/GaAsP strain-compensated SL was as short as 20.5 ps at room temperature (Fig. 2). The short lifetime causes the elimination of photo-excited electrons before emission. In order to evaluate the carrier lifetime effect on QE quantitatively, a simulation based on diffusion model [4] is being implemented and the results will be presented.

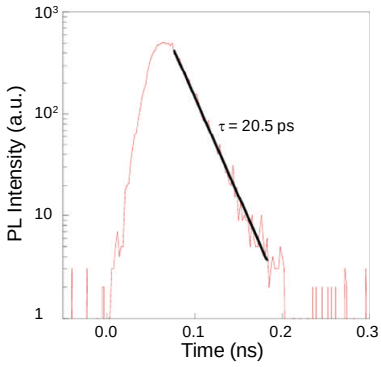

Fig. 2 Time-resolved PL for 24-pair GaAs/GaAsP strain-compensated SL.

[1] X.G. Jin *et al.*, Appl. Phys. Express, **1** (2008) #045002. [2] X.G. Jin *et al.*, Appl. Phys. Express, **6** (2013) #015801. [3] X.G. Jin *et al.*, Appl. Phys. Lett., **105** (2014) #203509. [4] P. Hartmann et al., J. Appl. Phys., **86** (1999) 2245.

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