MOCVD 法による Ge/Si 基板上 InAs/GaAs 量子ドットにおける GaAs 核形成層の成長温度の最適化

Optimization of Growth Temperature of GaAs Nucleation Layer in InAs/GaAs Quantum Dots on Ge/Si substrate by MOCVD

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Since the proposal of Arakawa and Sakaki, more than three decades ago, quantum dot (QD) lasers have found widespread commercial applications, due to their improved device characteristics, unattainable by quantum well lasers [1]. Ge-based Si substrate has been proposed as a potential platform for the monolithic integration of III-V-on-IV for silicon photonics application [2]. Though, QD laser directly grown on Ge/Si substrate has been demonstrated by MBE [3], for industrial application MOCVD is preferred and recently, we demonstrated electroluminescence from stacked InAs/GaAs QDs grown on Ge/Si substrate by MOCVD [4]. Here, we report on the effect of the growth temperature of the GaAs nucleation layer (NL) on the photoluminescence intensity of InAs/Sb:GaAs QDs monolithically grown on Ge/Si substrate by MOCVD.

A 1.0 μm thick GaAs buffer layer (BL) (Fig. 1 inset (a)) was grown on Ge/Si substrate by a three-step growth method [5]. A thin GaAs NL grown at low temperature, followed by a second layer grown at 500°C. The GaAs layer growth was completed at 650°C. The surface morphology and crystal quality of the GaAs BL is very sensitive to the NL growth temperature. Fig. 1 shows RT PL spectra of the capped InAs/Sb:GaAs QDs grown on Ge/Si substrate at different GaAs nucleation temperature. Of significance is that, the PL intensity of QDs is strongly dependent on the growth temperature of the GaAs NL, with the strongest intensity at 390°C, and is almost comparable to the reference QDs on GaAs substrate. The difference in the integrated PL intensity among various samples may be due to different density of defects generated at the GaAs/Ge interface and propagating into the III-V active region. This study is an essential step for the realization of a QD laser on Ge/Si substrate by MOCVD for silicon photonics application.

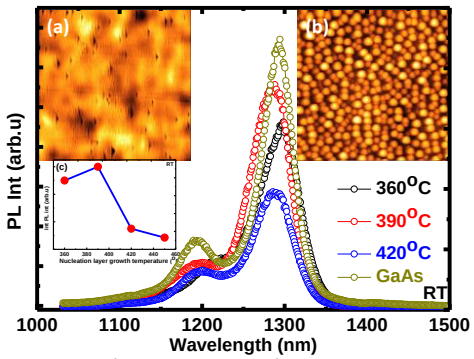

Figure 1. RT PL spectra of InAs/Sb:GaAs QDs grown on Ge/Si substrate with different GaAs nucleation layer (NL) growth temperature. Inset (a) shows 5 x 5 μm² AFM image of the GaAs buffer layer with the NL grown at 390°C, (b) 1 x 1 μm² AFM image of the uncapped InAs/Sb:GaAs QDs on GaAs/Ge/Si wafer, and (c) Integrated RT PL intensity of the QDs with different GaAs NL growth temperature.

Acknowledgements: This project is supported by JSPS, through the FIRST program, NEDO through the future pioneering project, and MEXT through the projects for Development of Innovative systems.
References: [1] Y. Arakawa and H. Sakaki: Appl Phys Lett. 40 (1982) 980. [2] M. Rajesh *et al.*, J. Cryst. Growth 315 (2011) 114. [3] A. Lee *et al.*, Opt. Exp. 20 (2012) 22181. [4] M. Rajesh *et al.*, Jpn. J. Appl. Phys. 53 (2014) 04H05. [5] M. Rajesh *et al.*, Appl. Phys. Exp. 4 (2011) 045201.