Photoluminescence Properties of GaSb/GaAs Quantum Dots Grown on Ge and GaAs Substrates

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Zero-dimensional quantum-dot (QD) nanostructure is an interesting structure for both study of physics and device applications [1]. Optoelectronic devices based on a combination of group IV and III-V materials systems might offer a new possibility for realizing novel devices. In this work, self-assembled GaSb/GaAs QDs have been grown on both GaAs and Ge substrates and their optical properties are investigated and compared. As shown in Fig. 1(a), a drastic blueshift of QD peak energy from 1.15 eV (QDs grown on GaAs substrate at 450ºC) to 1.23 eV (on Ge substrate at 450ºC) and a further shift to 1.33 eV (on Ge substrate at 500ºC) reveal the influence of substrate materials and growth temperature on optical properties of GaSb/GaAs QDs. Thermal activation energy E_a is extracted from the experimental results by fitting the integrated PL intensity of QDs peaks with Arrhenius's equation [2], as shown in Fig. 1(b). We attribute the low E_a values (20-56 meV) for all samples to the weak confinement potential for holes in our QDs, compared with 130 meV observed in the previous report [3]. The lower E_a values for QDs grown on Ge substrate than that of QDs grown on GaAs substrate are resulted from the smaller average height of QDs on Ge substrate. The QDs heights on Ge and GaAs substrates; ~5 nm and ~7 nm are observed by atomic force microscopy. This work enhances our understanding on the optical properties of GaSb/GaAs nanostructures when grown on various substrates and temperatures.

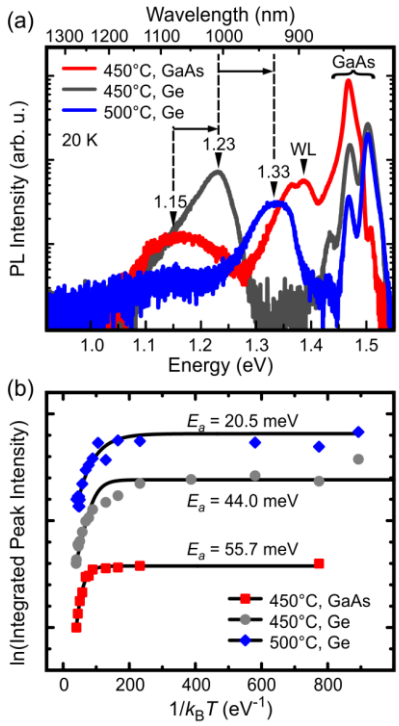

Fig. 1 (a) PL spectra of 3 ML GaSb/GaAs QDs and (b) Arrhenius plots fitted (lines) to the experimental results (symbols), showing thermal activation energies of QDs grown on Ge and GaAs substrates at different QDs growth temperatures. Integrated peak intensity is vertically shifted for clarity.

References: [1]Y. Arakawa and H. Sakaki, Appl. Phys. Lett. 40, 939 (1982). [2] R. Songmuang, S. Kiravittaya, M. Sawadsaringkarn, S. Panyakeow, O. G. Schmid, J. Crys. Grow. 251, 166 (2003). [3] K. Suzuki, R. A. Hogg, and Y. Arakawa, J. Appl. Phys. 85, 8349 (1999).