Quantum-Confined Direct-Gap Optical Absorption in Strained GeSn/Ge Multiple-Quantum-Well on Silicon

Kuan-Chih Lin○[1], Yen-Hsin Lo[2], Chi-Wang Im[2], and Guo-En Chang[1,2]

[1] Graduate Institute of Opto-Mechatronics, National Chung Cheng University, Taiwan

[2]Department of Mechanical Engineering, and Advanced Institute of Manufacturing with High-tech Innovations, National Chung Cheng University, Taiwan

E-mail: imegec@ccu.edu.tw

Narrow-bandgap GeSn material system has emerged as a promising platform for efficient Si-based infrared photodetectors (PDs) for a wide range of applications [1]. The realization of high-quality, high Sn-content GeSn alloys using low-temperature growth techniques [2] has led to the development of GeSn-based PDs with extended photodetection range [3]. Here we present a study of the growth and optical characterization of GeSn/Ge multiple-quantum-well (MQW) structures on silicon for efficient PDs on silicon.

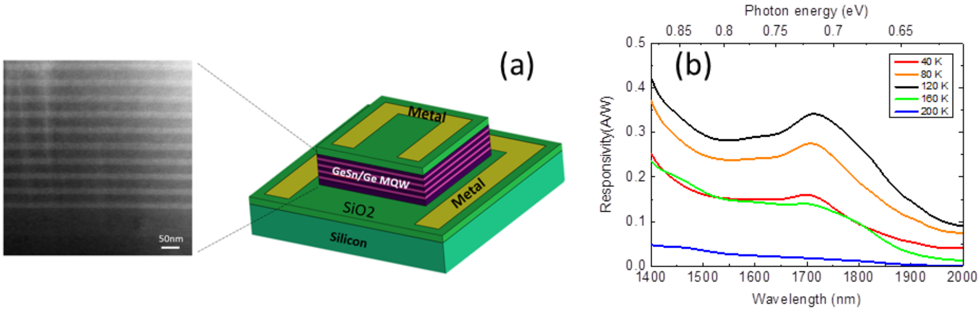

Fig. 1. (a) Schematics of GeSn/Ge MQW structure and TEM image, (b) temperature-dependent responsivity of the device.

The samples used in this study were grown on silicon substrates using low-temperature molecular beam epitaxy, consisting a 200 nm thick Ge virtual substrate (VS) and ten pairs of $Ge_{0.94}Sn_{0.06}$/Ge quantum wells with a thickness of 17/20 nm. The samples were then fabricated into a vertical metal-semiconductor-metal PD using CMOS-compatible fabrication process for optical absorption measurements, as shown in Fig. 1(a). Figure 1(b) shows the measured temperature-dependent responsivity of the fabricated device. The cutoff wavelength is extended to~2000 nm due to the introduction of Sn in the well region. It is worth noting that, as the temperature decreases, the responsivity spectra become step-like, providing evidence of the quantization of energy states in the system. These results confirm the quantum-confirmation in the GeSn/Ge MQW for novel electronic and photonic applications.

References

1. G. E. Chang *et al.*, IEEE J. Quant. Electron. **46**(12), 1813-1820 (2010).
2. G. E. Chang *et al.*, Opt. Lett. **38**(18), 3485–3487 (2013).
3. H. H. Tseng *et al.*, App. Phys. Lett. **102**, 182106 (2013)