Grating coupled Quantum Well Infrared Photodetector on a Si substrate

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Integration of III-V on Si has been widely studied due to the possibility of low-cost fabrication using Si substrate and excellent opto-electronic conversion efficiency of III-V material. The wafer bonding and epitaxial lift-off (ELO) techniques can transfer III-V layers on any substrates whose surface is clean and atomically smooth without changing material characteristics [1].

Quantum well infrared photodetectors (QWIPs) are currently used for two-dimensional long-wavelength infrared light detection due to the good uniformity produced by well-established MBE techniques. However, selection rules prevent quantum wells from absorbing normal-incidence light directly, so most usable QWIPs must incorporate grating couplers to convert TE light into TM light for absorption [2].

In this talk, grating coupled GaAs/AlGaAs QWIPs are fabricated on a Si substrate by means of metal wafer bonding (MWB) and ELO method for the first time. The GaAs/AlGaAs QWIPs which have 50 periods of quantum wells (QWs) are grown by MBE. The grating was designed with a hexagonal periodic hole array structure and fabricated by dry-etching. After fabricating the grating structure, thin Pt/Au materials were deposited on the both detector and Si substrate. Two substrates were pressed and then dipped into the HF solution for ELO process. The final device was completed after metallization on the transferred QWIP layer on a Si substrate.

Our results show remarkable improvement compared to previous attempts to fabricate grated QWIPs. Previously, grated QWIPs were integrated with Si using In-bumps saw only a relatively small increase in photocurrent compared to the un-grated structure [3]. However, as seen in Fig. 1, our grated shows 17 times higher intensity compared to the QWIP on a Si substrate without grating structure. This significant increase may be attributed to both the optical resonance cavity effects and increased light absorption of TM component.

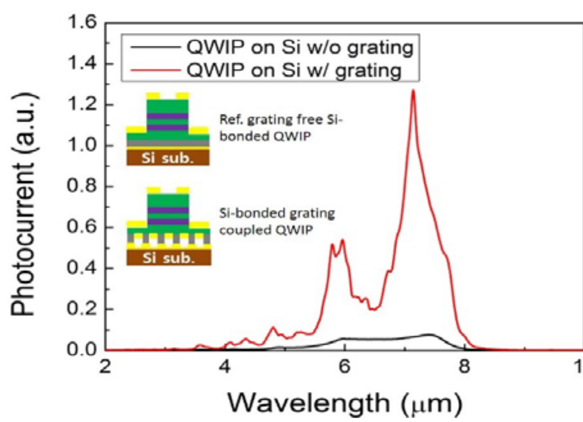

Figure 1. Photocurrent spectra of the GaAs/AlGaAs QWIP with and without grating on

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[3] F. M. Guo, D. Y. Xiong, W. E. Zhang, and Z. Q. Zhy, Infra. Phy. Tech. **52**, 276 (2009)

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Supplementary Information:

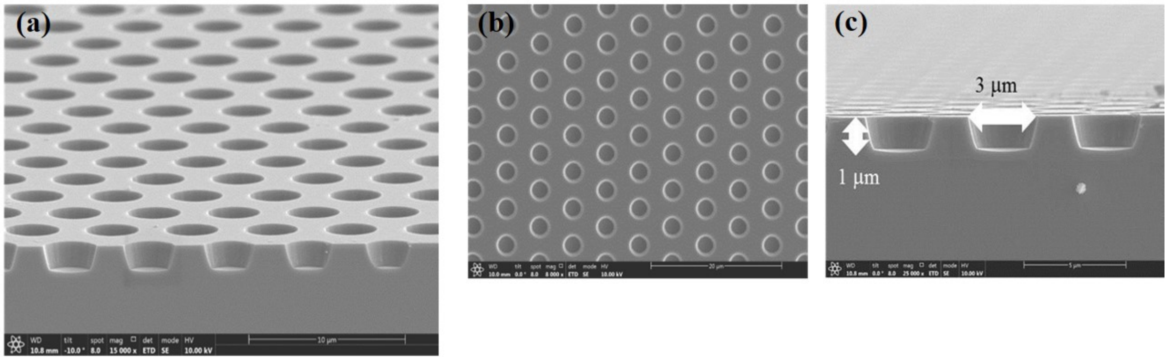

Figure 2. SEM image of the grating structure (a) in bird view, (b) in top view and (c) in cross-section view.

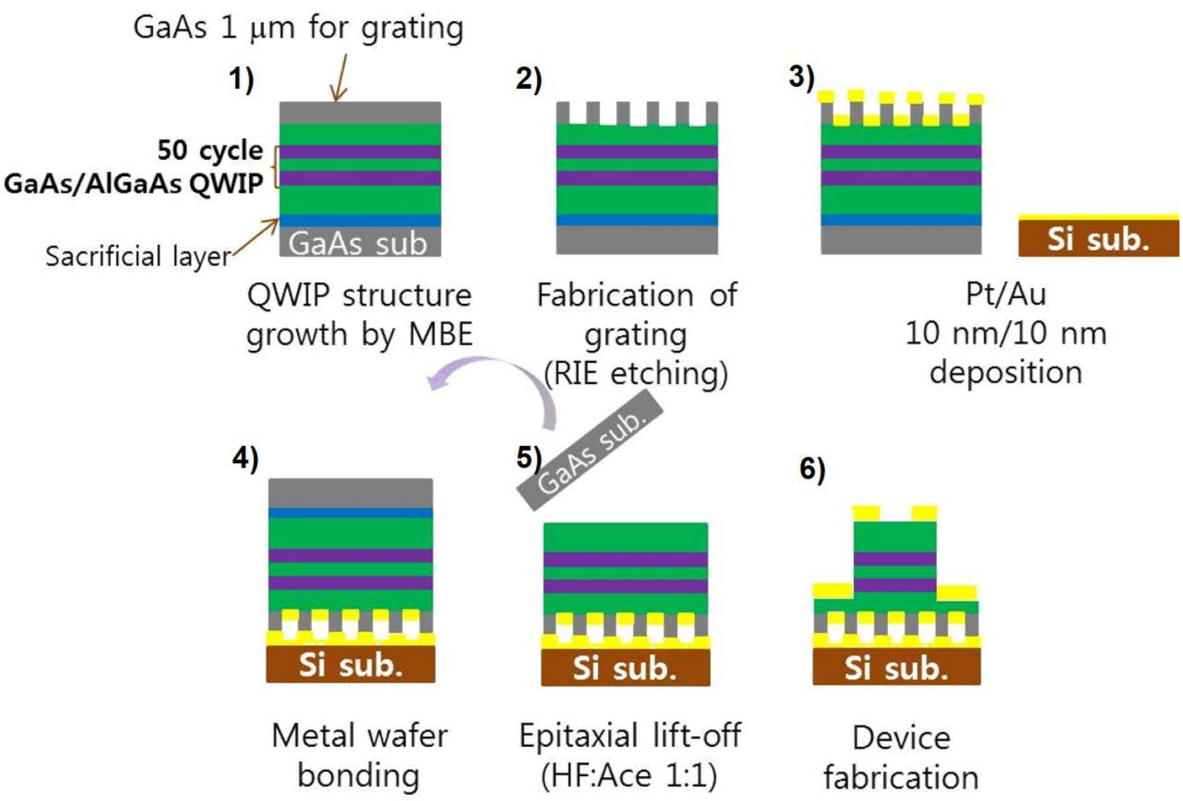

Figure 3. The structure of GaAs/AlGaAs QWIP and the fabrication flow of the grating coupled QWIP on Si substrate by means of metal wafer bonding and epitaxial lift-off.