CMOS logic devices and gas sensors realized by epitaxially transferred 2-D III-V nanoribbons on insulator

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Epitaxial lift-off and transfer of crystalline micro/nano structure to various substrates [1, 2] have been extensively used to study and realize low dimensional electronic devices [3]. The epitaxial transfer technique allows integrating different crystalline materials with large lattice mismatch on the same substrate. In addition, it can be used for the study of low dimensional physics and device applications by precisely controlling the dimensions of the transferring materials. In this presentation, we will discuss the performance of the CMOS (complementary metal-oxide-semiconductor) logic devices and gas sensors, realized by epitaxially transferred III-V nanoribbons (NRs) on insulator.

The performances of III-V only CMOS logic device have not been demonstrated due to difficulties in epitaxially growing *n*- and *p*-type materials on the same substrate. As an alternate approach, we epitaxially transfer MBE-grown InAs for *n*-channel and InGaSb for *p*-channel on the same Si/SiO_2 substrate and fabricated proof-of-concept CMOS logic gate devices, such as inverter and NAND gate, highlighting the potential of this approach for obtaining heterogeneous III-V electronics on conventional Si substrates [4].

Next, we investigated the role of size effect on the performance of gas sensors, using epitaxially transferred two- dimensional InAs membranes [5]. For this study, InAs membranes with different thicknesses (8, 18, 48 nm) were decorated with Pd (palladium) and the sensor response was investigated at different H_2 concentrations. Through detailed experiments and modeling, the thickness scaling effect was systematically studied. The results showed two orders of magnitude higher sensor response in a 8nm thick InAs membrane by comparison to 48 nm one, indicating the roles of size scaling. In addition, Pd-decorated InAs NR hydrogen gas sensor showed strong sensor response down to ppm levels exposure to H_2. Lastly, using non-functionalized ultrathin InAs NRs, NO_2 gas was detected. The sensor demonstrated the responses down to 10 parts-per-billion (ppb) levels at room temperature and the predominant reaction to NO_2 exposures was observed. [6]

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References

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