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Carbon nanotube and MoS_2 hybrid film for high performance flexible gas sensor

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There are many interests in chemical sensors with low dimensional materials such as graphene, single-walled carbon nanotube (swCNT) and molybdenum disulphide (MoS_2). We fabricated a novel MoS_2 and swCNT hybrid film which applied to chemical gas sensor with excellent flexibility for the highly-sensitive detection of specific gases. We believe that the hybrid film exhibited the higher gas sensing performance compared to the pristine MoS_2. Because the hybrid film was a significantly enhanced surface area compared to pristine MoS_2. In addition, a hybrid film was able to apply to flexible devices, such as gas sensors and transistors. Confirmed from our measurements, the film has a high sensitivity to NO_2 and NH_3, as well as its excellent flexibility through the bending test. Our results suggest that a hybrid film showed a possibility that can be used as a flexible sensor in the future.

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Fabrication of In-Rich(〉0.53) InGaAs-OI on Si by Novel Epitaxial Lift-Off

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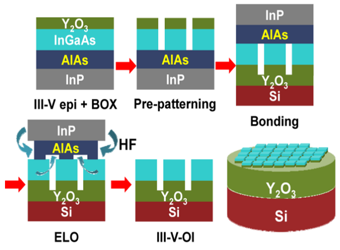
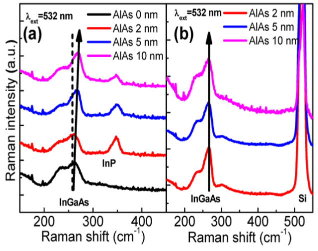
An In-rich InGaAs is expected to be the most attractive channel for the next-node transistors due to their high electron mobility. Recent studies demonstrated high performance InGaAs MOSFETs with highly scalable device structure such as nanowire, fin, and ultra-thin-body (UTB). Meanwhile, from a viewpoint of the mass-production, the current key issue is a cost-effective integration of III-V materials on a Si platform. There were many attempts such as direct growth on Si [1], direct wafer bonding (DWB) [2], and aspect ratio trapping [3]. However, growth-based methods suffer from the defect control due to the large lattice mismatch between III-V and Si. The DWB is a promising technique for good epitaxial quality, whereas many studies use high cost process such as etch-out of the donor substrate.

In this study, $In_{0.53}Ga_{0.47}As$-OI/Si wafer was fabricated by DWB and epitaxial lift-off (ELO) as shown in Fig. 1. First, $In_{0.53}Ga_{0.47}As$ (15 nm, undoped)/AlAs (sacrificial layers) layers were epitaxially grown on InP(100) substrate by MOCVD. The thickness of AlAs (T_{AlAs}) was varied between 0 and 10-nm in order to explore the InGaAs quality and the ELO time. Subsequently, a 10-nm-thick Y_2O_3 layer was deposited both on III-V($In_{0.53}Ga_{0.47}As$/AlAs/InP) and Si wafers. Prior to DWB, the donor wafers were pre-patterned for a fast ELO via efficient gas bubble release and increase of the exposed etching area. Here, the pattern size was fixed to be 100 ◈ 100 μm^2. Then, $Y_2O_3/In_{0.53}Ga_{0.47}As$/AlAs/InP substrate and Y_2O_3/Si substrate were directly bonded to each other. Finally, $In_{0.53}Ga_{0.47}As$-OI/Si substrates and InP donor wafer were separated by the selective etching of the AlAs layer in HF solutions. After DWB and ELO process, the Raman spectra of $In_{0.53}Ga_{0.47}As$ /Y_2O_3/Si substrate shows both sharp peaks of $In_{0.53}Ga_{0.47}As$ and Si, indicating successful fabrication of high-quality III-V-OI/Si as shown in Fig. 2. The cross-sectional TEM images of fabricated $In_{0.53}Ga_{0.47}As$-OI on Si substrate evidently represent excellent crystal quality and bonding interface, resulting in the successful DWB as shown in Fig. 3.





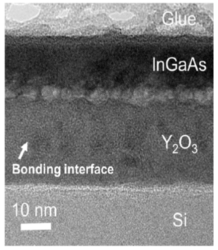


Fig. 1. Process flow of InGaAs-OI wafer (**left**). Fig. 2 Raman spectra of InGaAs layer (a) before (b) after bonding **(center)** Fig. 3. Cross-sectional TEM image of InGaAs-OI wafer **(right)**