The Improvement of Hole Gas Accumulation in Al-Catalyzed SiNW/i-Ge Core-Shell Structure by B-Doped Outermost Si Shell Formation

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Core-shell nanowire (NW) structures have recently attracted great attention for high electron mobility transistors due to their remarkable electrical and mechanical properties. From our previous reports [1-2], the vapor-liquid-solid (VLS) growth using Al catalyst could create single crystalline SiNWs with the resolving of metal catalyst contamination problem. The hole gas accumulation [3-4] in unintentional Al doped p-Si/Ge core-shell structure were observed in i-Ge shell region. However, the carrier concentration of unintentional Al doping from catalyst as p-type dopants in SiNWs was limited and difficult to further increase by adding of B doping, resulting in the limit of hole gas density. Therefore, in this study, the effects of various B doping in p-Si shell outermost layer in the p-Si/i-Ge/p-Si core-double shell NW structure on the hole gas generation were investigated.

All samples were fabricated on n-Si (111) substrates. Al-catalyst films were sputtered prior to VLS process. The SiNW formation was performed with a growth time of 30 min, a SiH_4 gas flow of 19 sccm, and a fixed substrate temperature of 700 °C. The Ge shell layer was deposited at 500 °C for 90 sec with a GeH_4 gas flow of 10 sccm. The outermost Si shell was provided by a SiH_4 gas flow of 19 sccm and various B_2H_6 gas flow rates of 0.1, 0.3, and 0.5 sccm at 700 °C for 60 sec. Figure 1 shows schematic, band diagram, and SEM images of Al-catalyzed SiNW/Ge/B-doped Si core-double shell formation with various B_2H_6 flow rates. The enhance of hole gas generation by outmost shell regions were expected. The increasing of B doping slightly increased p-Si outermost shell thickness and core-double shell NW diameter.

The Raman spectra of Ge optical phonon peaks of core-double shell NWs with various B_2H_6 flow rates in outermost Si shell compared to bulk-Ge, and core-shell NWs were plotted in Fig. 2. All Ge optical phonon peaks of core-shell NWs and core-double shell NWs with increasing of B doping in Si outermost shell clearly showed asymmetric broadening. The Ge optical phonon peaks of core-double shell NWs were downshifted from that of bulk-Ge to a lower value with a higher B_2H_6 flow rates. These results indicated the Fano effect in i-Ge regions. Fano function was used to fit the Ge optical phonon peaks to calculate the hole gas density in i-Ge region. The improvement of hole gas generation by adding of B doping in p-Si shell outermost layer were proofed. More detailed explanations of characterizations and crystalline properties will be discussed on site.

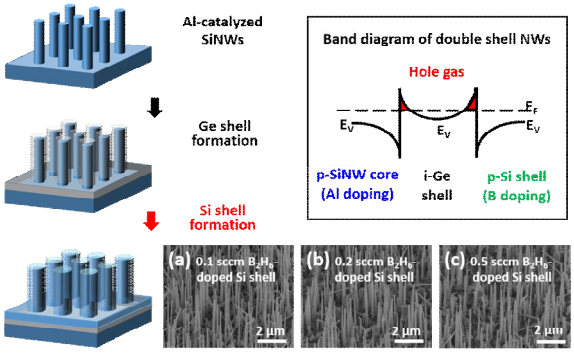

Fig. 1 Schematic, band diagram, and SEM images of Al-catalyzed SiNW/Ge/B-doped Si core-double shell formation with various B_2H_6 flow rates of (a) 0.1, (b) 0.3, and (c) 0.5 sccm in outermost Si shell.

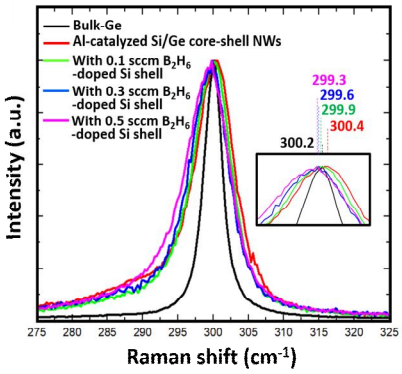

Fig. 2 Raman spectra of Ge optical phonon peaks of bulk-Ge, Al-catalyzed SiNW/Ge core-shell structure, and Al-catalyzed SiNW/Ge/B-doped Si core-double shell structures with various B_2H_6 flow rates of 0.1, 0.3, and 0.5 sccm in outermost Si shell.

Reference:
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