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Thermal Stability Enhanced Ge/graphene Core/shell Nanowires

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Semiconductor nanowires (NWs) are future building block for nano-scale devices. Especially, Ge NWs are fascinated material due to the high electrical conductivity with high carrier mobility. It is strong candidate material for post-CMOS technology. However, thermal stability of Ge NWs are poor than conventional semiconductor material such as Si. Especially, when it reduced size as small as nano-scale it will be melted around CMOS process temperature due to the melting point depression. Recently, Graphene have been intensively interested since it has high carrier mobility with single atomic thickness. In addition, it is chemically very stable due to the sp^2 hybridization. Graphene films shows good protecting layer for oxidation resistance and corrosion resistance of metal surface using its chemical properties. Recently, we successfully demonstrated CVD growth of monolayer graphene using Ge catalyst. Using our growth method, we synthesized Ge/graphene core/shell (Ge@G) NW and conducted it for highly thermal stability required devices. We confirm the existence of graphene shell and morphology of NWs using SEM, TEM and Raman spectra. SEM and TEM images clearly show very thin graphene shell. We annealed NWs in vacuum at high temperature. Our results indicated that surface melting phenomena of Ge NWs due to the high surface energy from curvature of NWs start around 550^{o}C which is 270^{o}C lower than bulk melting point. When we increases annealing temperature, tip of Ge NWs start to make sphere shape in order to reduce its surface energy. On the contrary, Ge@G NWs prevent surface melting of Ge NWs and no Ge spheres generated. Furthermore, we fabricated filed emission devices using pure Ge NWs and Ge@G NWs. Compare with pure Ge NWs, graphene protected Ge NWs show enhancement of reliability. This growth approach serves a thermal stability enhancement of semiconductor NWs.

Keywords: germanium, nanowire, graphene, reliability, stability