The Materials Integration of Ge and $In_xGa_{1-x}As$ on Si Template for Next Generation CMOS Applications

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Lately, the semiconductor industry has paid a lot of attentions to the III-V compound semiconductor materials such as InSb, $In_xGa_{1-x}As$ for next generation CMOS applications, because these materials have significantly higher carrier mobility than silicon. For example, the electron mobility of InAs could reach 20000 $cm^2V^{-1}s^{-1}$. High-speed devices such as quantum-well field-effect transistors (QWFETs) made from these III-V materials have demonstrated very low gate delay time. However, hole mobility for III-V materials are very low in general, some are even lower than the hole mobility of Si. So, it is important to look for a proper material with high hole mobility as p-channel FETs for future complementary CMOS architecture. Since Ge has a much higher bulk hole mobility (μ_h =1900 cm^2/Vs) as compared to GaAs (μ_h = 400 cm^2/Vs), Ge is suitable as p type channel material. Due to the small lattice mismatch (~0.08%) between GaAs and Ge, the integration of Ge with GaAs is comparable easy as compared to grow on Si , therefore thick Ge film can be grown as channel on GaAs substrates with very low defect density and integrate with $In_xGa_{1-x}As$ devices as a CMOS structure. In this talk, the growth of high quality Ge film on GaAs substrate by ultra high vacuum chemical vapor deposition (UHVCVD) and high quality InAs material on Ge/SiGe/Si template grown by molecular beam epitaxy (MBE) will be particularly reported. By the observation of XRD and AFM, both Ge film grown on GaAs material and InAs grown on Si substrates demonstrate high crystallinity and good surface morphology. The developed epitaxial materials systems including Ge on GaAs and InAs on Si are useful for future III-V/Ge/Si integration for next generation high speed low power CMOS application as well as for RF/digital mixed signal circuit application in the future.

KEYWORDS

GaAs, InAs, Ge, complementary structure