Heteroepitaxial growth of Silicon on GaAs via low temperature plasma-enhanced chemical vapor deposition

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Integration of III-V materials on silicon has been and still is a challenging subject due to lattice and thermal mismatch effects, as well as to the polarity issues at the interface which result in a high density of defects. To overcome these difficulties, we present here an original inverted metamorphic growth process where silicon is epitaxially grown on GaAs by low temperature plasma-enhanced CVD (PECVD). Without the need for ultra-high vacuum and keeping the substrate temperature around 200°C, both an in-situ GaAs surface cleaning and a subsequent heteroepitaxial growth were achieved [1]. The good electronic quality of the low temperature epi-Si and epi-SiGe layers has been demonstrated by making heterojunction solar cells on highly doped (100) oriented c-Si substrates [2]. Moreover, aiming at tandem devices, we have also fabricated hybrid tunnel junctions where we combine low temperature RF-PECVD for Si and metalorganic vapor phase epitaxy (MOVPE) for GaAs [3]. The electrical properties of these heterojunctions are measured and compared to that of a reference III-V tunnel junction. The presence of atomic hydrogen during the epi-PECVD of silicon on GaAs strongly reduces the doping level at the surface of GaAs. Indeed, 30 seconds of H_2 plasma exposition at 175 °C are sufficient to reduce the GaAs film doping level from 1.10^{20} cm^{-3} to less than 2.10^{19} cm^{-3} at the surface and over a depth of about 20 nm. Fortunately, the doping level can be fully recovered after annealing at 350 °C.

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