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Doping Issues in III-V CMOS Technology

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Future generations of CMOS devices call for increased device performance at ever decreasing node sizes. As further size reductions become increasingly challenging due to increased power density and fixed drive currents, there is a growing interest in alternative higher mobility channel materials to meet CMOS performance targets in the future. Compound III-V semiconductors such as GaAs, InGaAs, and InP are some of the most promising n-channel materials for meeting these requirements due to their vastly superior electron mobilities compared to silicon. There are many challenges that come integrating these materials into devices with current processing technologies. One such challenge is the creation of ultra shallow junctions and low sheet resistance contacts. Ion implantation of III-V materials was studied extensively in the 70's and 80's and interest in these materials has recently been increasing again with this new opportunity. Because of the high electron mobilities much of the interest has focused on N-FETs. This talk will review the literature as it relates to the most common n-type dopants, both group IV and group VI elements in GaAs, InGaAs and InP. In general donor concentrations in III-V semiconductors are lower than those observed in Si making this an area of interest if these materials are going to be integrated with minimal resistance. This talk will review implantation based doping studies including basic properties such as implant and annealing challenges and their effect on diffusion and solubility limits. In addition concepts foreign to Si such as the role of co-implants to facilitate site selection in amphoteric species will be discussed. Finally recent studies using lower energy implants and the effect of varying the implant temperature to avoid amorphization will be presented. Hall studies after RTA show there is no measurable activation upon solid phase epitaxial growth (SPEG) of amorphized InGaAs and that SPEG actually significantly delays dopant activation. The stacking fault defects that arise from SPEG of lower energy implants are shown to be very stable to 850°C and avoiding amorphization via elevated temperature implant is desirable. Finally previous studies of elevated temperature implants will be reviewed and recent results of elevated temperature Si+ implants in InGaAs and InP will be presented.