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B-3-1 (Invited) ION IMPLANTATION INTO COMPOUND SEMICONDUCTORS

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At present ion implantation into Si is an essential process for fabricating integrated circuits. Although the applications of the technique into various compound semiconductors are still limited, there are steadily growing areas of them especially in the fabrication of optical and microwave devices. This paper presents the technical state of the implantation into compound semiconductors focussing onto GaAs which is the most commonly used material among them.

Currently, there is considerable interest in the use of GaAs for high speed IC's which, we believe, is difficult to achieve by using Si.[1] One of the most promissing approach to realize them is to implant donor ions into Cr-doped semi-insulating substrates to selectively form n-type active layers. In this case the electrical properties of the active layer are strongly related to the redistributed Cr atoms in the implanted layer.[2] From the substrates commercially available today, a good quality of n-type layer with mobility in the range of 4000 cm^2/V.sec can be obtained reproducibly. A doping uniformity of about 3 % can be attained in an inch square wafer. Both the electrical properties and the uniformity could be more improved if the residual impurities in the substrates are reduced to a level about one order of magnitude lower than the present one.

It is very important to understand the behaviors of the compensators doped in semi-insulating substrates, especially Cr, during the thermal annealing process of the implanted layer. Recent works[3,4,5] using SIMS analysis have revealed that the redistribution of Cr atoms obays to a simple thermal diffusion theory until the dose exceeding the critical one around 10^{14} cm^{-2}. A pronounced accumulation of Cr atoms observed at the surface depends on the annealing conditions. Gettering effects have been observed at the implanted damaged region and at the interface between the implanted layer and the substrate. These phenomena make it complicated to understand the annealing behaviors of high dose implanted GaAs. Another important factor influencing the Cr redistribution is the coulombic interaction[6] between Cr atoms and the extrinsic donor atoms which occurs when the implanted donor density exceeds the intrinsic carrier concentration at the annealing temperature. In addition to the difficulties in controlling the stoichiometry of GaAs, particularly at the surface, this might be a reason why it is generally much more difficult to achieve n^+ layer than p^+ one.

Implantation of H^+ or O^+ ions into compound semiconductors to form high resistivity layers is an alternative way for forming electrically isolated field regions of GaAs IC's as well as for the isolation of laser diodes and LED's. Discussions on this technique will be presented, and the state of the implantation doping into other compounds such as InP and ternary and quaternary compound semiconductors will be reviewed.

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