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Abstract for the report form: A new approach for n-type modulation doping in In-based heterostructures is proposed where intrinsic defects from low-temperature (LT) grown InP are utilized to provide charge carriers without an external shallow impurity doping source. The success of this approach is demonstrated by results from InGaAs/LT-InP heterostructures, where doping is provided by P_{In} antisites, introduced during off-stoichiometric LT growth of InP. Photoluminescence in a magnetic field and Shubnikov-de Haas oscillations are applied for characterizing the electronic structure and recombination mechanisms. The efficiency of electron transfer and quantum mobility of a two-dimensional electron gas formed near the heterointerface is shown to be much higher as compared to traditional extrinsic doping.

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Low-Temperature Grown III-V Semiconductors

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The ability in tailoring electronic properties by doping of impurities has made semiconductors the backbone for modern electronics. Rapid developments in innovative growth techniques and new device structures in recent years have urged a better and deeper understanding of dopants and doping processes. Selective or modulation doping represents one of the essential steps in fabrication of modern devices based on InP-based heterostructures, which are now well recognized as being among the most promising electronic material systems for applications in optoelectronics and high-frequency electronics. Such doping has traditionally been done by extrinsic doping, i.e., by incorporating shallow impurity donor or acceptor dopants in the structure.

We have proposed a new and different approach for n-type modulation doping in InP-based heterostructures, namely, intrinsic doping, where intrinsic defects are utilized to provide the required doping without an external doping source. The success of such an intrinsic doping concept is clearly evident from our results obtained from low-temperature (LT) non-stoichiometric growth of InP as the donor layer for the GaInAs channel in a GaInAs/LT-InP modulation-doped structure. Shubnikov-de Haas oscillations and photoluminescence in a magnetic field were performed by our collaborators at Linkoping University in Sweden, under Prof. Weimin Chen. They found that the efficiency of electron transfer and quantum mobility of a two-dimensional electron gas (2DEG) formed near the heterointerface are much higher as compared to traditional extrinsic doping.

Furthermore, the GaInAs/LT-InP samples and the control sample of GaInAs/n-InP grown at normal growth temperature with Si doping are characterized by optical perturbation spectroscopy (optical detection of quantum oscillations via photoluminescence in a magnetic field) to obtain information about the electronic structure and radiative recombination mechanisms under equilibrium and non-equilibrium conditions. In addition, the presence of the Fermi-edge singularity in photoluminescence spectra of these samples is found to be strongly dependent on the 2DEG concentration. This dependence presumably reflects intrinsic properties of the two-dimensional system. The Fermi-edge singularity represents an enhanced oscillator strength for optical transitions at the Fermi edge caused by the Coulomb interaction between the photo-created electron-hole pair and electrons at the Fermi sea (for n-type doping).