Preface

This monograph reports the findings of a detailed investigation of the impact of ion implantation on the material, electrical and spectral properties of In(Ga)As/GaAs quantum dot (QD) heterostructures.

Over the past two decades, In(Ga)As/GaAs-based QD heterostructures have marked their superiority, particularly for application in lasers and photodetectors. Several in-situ and ex-situ techniques that improve material quality and device performance have already been reported. These techniques are necessary to maintain dot density and dot size uniformity in QD heterostructures and also to improve the material quality of heterostructures by removing defects from a system. While rapid thermal annealing, pulsed laser annealing and the hydrogen passivation technique have been popular as post-growth methods, ion implantation had not been explored largely as a post-growth method for improving the material properties of In(Ga)As/GaAs QD heterostructures. In the present study, we attempted to employ ion implantation as an effective post-growth technique to improve the material properties and, ultimately, the device performance of In(Ga)As/GaAs QD heterostructures. Also, we introduced a capping layer of quaternary alloy InAlGaAs over these In(Ga)As/GaAs QDs to achieve better QD characteristics. With these intensions in mind, the below content had been divided into five chapters as follows: Chap. 1 details the physics of zero-dimensional structures and the electronic properties of QDs. The chapter also discusses different QD fabrication techniques. We address different shortcomings of QDs followed by methods to improve the QD characteristics for In(Ga)As/GaAs QDs. Chapter 2 deals with the impact of both low-energy heavy ion (sulphur) and low-energy light ion (hydrogen) implantations over single-layer InAs/GaAs QDs. The material and structural properties of both un-implanted and implanted QDs are discussed, along with the results achieved through different characterizations. Sulphur (S^{-}) ion implantation caused degradation of material quality, whereas hydrogen (H^{-}) ion implantation improved the material properties of InAs/GaAs QDs. In Chap. 3, the structural and optoelectronic properties of quaternary alloy (InAlGaAs)-capped multilayer QD heterostructures were investigated by varying growth rate, capping layer thickness, and seed QD monolayer coverage. In addition, when all the samples were annealed at various temperatures, the results showed that structural and optoelectronic properties are greatly influenced by annealing temperatures. In Chap. 4, we validate the impact of ion implantation over devices; quaternary alloy-capped InAs/GaAs QDIP devices were implanted with low-energy light ions (H^-). Different steps to fabricate single pixel devices are also discussed in this chapter. A suppression of dark current density was observed for the implanted devices. In Chap. 5, low-energy light ion (H^-) implantations were performed over quaternary alloy-capped InGaAs/GaAs QDIPs. A reduction in dark current density along with enhanced detectivity was measured for the implanted devices.

Mumbai, India

Arjun Mandal
Subhananda Chakrabarti

http://www.springer.com/978-981-10-4333-8

Impact of Ion Implantation on Quantum Dot
Heterostructures and Devices
Mandal, A.; Chakrabarti, S.
2017, XXIII, 64 p. 53 illus., 32 illus. in color., Hardcover
ISBN: 978-981-10-4333-8