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Professor Gunshor

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Purdue Research Foundation
1063 Hovde Hall
West Lafayette IN 47907-1063

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The study focused on providing an explanation for the puzzling increase in the resistivity of the ZnSe alloys (doped with nitrogen) as the bandgap energy increased. When laser diodes are fabricated at wavelengths which move them further into the blue, it was found that the electrical performance tends to degrade by an apparent incrase in the resistivity of the wider bandgap constituents.

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AASERT Program
Electrical Properties of Blue Laser Diodes
Principal Investigator: Robert L. Gunshor
Grant No. F49620-94-1-0395
Period covered: July 1, 1994 to July 31, 1998

The first year of the AASERT concentrated on the measurement of transport properties of p-ZnSe and the p-type wide bandgap alloys of ZnSe, and also means for improving the control of substrate temperature during film growth. The AASERT grant supported the student, Mike Ringle, who carried out the study briefly described here. Much of the electronic test equipment used in the study was provided by Hewlett Packard as a gift in support of our blue/green light emitter program.

The study focused on providing an explanation for the puzzling increase in the resistivity of the ZnSe alloys (doped with nitrogen) as the bandgap energy increased. When laser diodes are fabricated at wavelengths which move them further into the blue, it was found that the electrical performance tends to degrade by an apparent increase in the resistivity of the wider bandgap constituents. The origin of the increase in resistivity was unknown prior to this study. The transport study revealed that the increased resistivity was due to an apparent increase in the acceptor activation energy. Whereas nitrogen behaves as a hydrogenic acceptor in ZnSe, it was found that nitrogen formed a deep level through a local lattice relaxation about the impurity. In fact, the behavior was quite similar to the formation of a DX center, a common phenomenon in n-type AlGaAs above some aluminum fraction. The impact of this discovery was twofold. on one hand it provided an explanation for the heretofore not understood anomalous increase in resistivity in the wide bandgap alloys of ZnSe, and on the other hand, the discovery has interested the theoretical solid state community as DX-like behavior has not previously been observed for acceptors in any p-type semiconductor.

During the second year of the grant, the emphasis of the AASERT project was changed from the II-VI to the group III nitrides as the material basis for the development of blue/green laser diodes. The student who had been working on the transport issues in p-type wide bandgap alloys of ZnSe graduated with his Masters degree and moved to a position with Intel. The next student supported by the AASERT grant, Troy Gilbert, was more interested in our group III nitride effort, hence the change in direction.

The effort began in collaboration with Hewlett-Packard who supplied us with MOCVD-grown (on sapphire) GaN epilayers employed in lieu of direct substrates for subsequent MBE growth. The objective was the exploration of means for improving the quality of quantum well structures in the nitride system.

During the next period covered by this report, there was no activity as we were trying to recruit a suitable candidate to replace Troy Gilbert (The AASERT student), who left to join the Livermore Laboratory in lieu of pursuing his graduate work at this time. Consequently, there was no expenditure charged to the grant during this period.

Starting in August 1997, a new student, Jay Hamilton, who began graduate studies in the School of Electrical and Computer Engineering at Purdue with an undergraduate background in Chemical Engineering, joined our group and was to be supported by the AASERT grant (by means of a no-cost extension). He was working on the group III-nitrides as part of our AFOSR program aimed at the solution of some key materials problems in the development of wide bandgap group III-nitride devices. It was intended that he implement the new on-line in situ AFM/STM for the purpose of a study of interface morphology resulting from the MBE growth of (Al,Ga,In)N structures. After spending some time learning the details of MBE growth, he decided that some computer modeling study would be more to his interest, and he switched out of the MBE project. At that point further expenditure of the AASERT funds ceased.