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Spectroscopy of Single Free Standing Quantum Wells

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Spectroscopy of Single Free Standing Quantum Wells

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We investigated the interaction of quantum confined exciton states GaAs quantum wells with native surface states. Single molecule photoluminescence (PL) spectroscopy, developed by T. Huser at LLNL was used to probe the unique bare quantum wells in the free standing quantum well structure. The latter was developed by the M. D. Williams at Clark Atlanta University. The goals of the project during this budget cycle were to procure samples containing GaAs free standing QWs, identify suitable regions for PL analysis at Lawrence Livermore, analyze the structures at room temperature and at liquid nitrogen temperatures. The specific regions of interest on the sample structures were identified by scanning electron microscopy at Clark Atlanta prior to transport to LLNL. Previous attempts at other facilities using NSOM, cathodoluminescence, and conventional PL showed little luminescence activity at room temperature from the 200 Å thick wells. This suggested either excess recombination due to surface states in the quantum well region or insufficient absorption length for photoluminescence. The literature suggested that the effect of the defects could be eliminated by reducing the sample temperature below their associated activation energies. In our previous subcontract work with LLNL, a significant amount of effort was expended to modify the apparatus to allow low temperature measurements. The modifications were not successful and we concluded that in order to do the measurements at low temperature we would need to purchase a commercial optical cryostat to get reliable results. Ms. Rochelle Bryant worked during the summer as an intern at LLNL on the project under the supervision of C. Hollars and in collaboration with T. Huser and found that PL emission could be obtained at room temperature. This was a surprising result as the literature and our experience shows that there is no PL emission from GaAs at room temperature. We speculate that this is due to the small interaction region excited by the laser source. We proceeded with the project using this new found room temperature capability and have analyzed the effect of various chemical species on the PL emission from the GaAs QWs. We were able to observe some significant intensity modifications of the PL spectra with chemical adsorbants. This progress holds promise for the development of this structure as a chemical or biological sensor.

Mr. Cochran and Ms. Jallow have utilized what Ms. Bryant learned in this interaction and applied it to the design and fabrication of a PL spectroscopy system at Clark Atlanta University. Ms. Jallow is analyzing the collected data for intensity and lineshape variations, with respect to absorbate species, as part of her MS thesis project. This work will be reported in the scientific literature and at technical meetings with proper acknowledgment to the LLNL RCP program. Jallow is scheduled to graduate in May 2007. Cochran is a Ph.D. candidate in the Systems Science Ph.D. program and will use the PL setup here at Clark Atlanta to analyze polymer samples for a biological physics project.

We wish to acknowledge and thank Dr. Kennedy Reed for his making this collaboration possible. Three students have obtained their MS degrees in Physics (Ms. Shala Mance, Ms. Sharah Yasharahla, and Ms. Adwoa Gyekye) and one obtained the BS degree (Mr. Jason Collins) from Clark Atlanta as a result of previous collaborations under this program. The BS recipient went on to obtain the MS degree in computer engineering.