Mr. Dustin Guidry started working in our lab in June as a Physics Research Development Standardization Group in UK and Professor Robert Sivrananthan and Professor Tae Won Kang from Quantum Functional Semiconductor Research Center of Dongguk University in South Korea attended this year’s symposium in South Korea. The Symposium on Functional Semiconductor Research was held in the United States from June 27th to July 1st, 2004 at the University of Illinois at Chicago. The Microscopy Laboratory (MPL) at UCF has maintained a lead role in the growth technology and device fabrication of InGaAsP for the past sixteen years. InGaAsP is used in the strategically important field of infrared (IR) detection, in particular for sensors used for night vision equipment deployed by the US armed forces and for IR remote sensing in NASA satellites. However, as is less well known, MPL also has applied its superior expertise and experience in heteroepitaxy to obtain outstanding results in the growth, characterization and modeling of heterostructures made from all types of semiconductor materials and even metal/semiconductor heterojunctions. The MPL’s achievements in heteroepitaxy are summarized in this issue of our report.

HETEROEPITAXY

In the physics of solid state materials “epitaxy” is understood to mean the controlled growth of an artificial crystalline layer on a crystalline substrate. The word epitaxy is derived from the Greek words “epi” meaning “upon” and “taxis” meaning “order.” In this paper, the substrate crystal acts as a material template or mold that forces the atoms deposited on it to form a crystalline structure. In “heteroepitaxy,” the impinging atoms form the artificial crystal layer and even the same as the atoms of the substrate. In the case of heteroepitaxy, the substrate and the deposited ultrathin layer (ranging from several atomic layers to thousands of layers) have different chemical compositions. In the physics of solid state materials “epitaxy” is understood to mean the controlled growth of an artificial crystalline layer on a crystalline substrate. The word epitaxy is derived from the Greek words “epi” meaning “upon” and “taxis” meaning “order.” In this paper, the substrate crystal acts as a material template or mold that forces the atoms deposited on it to form a crystalline structure. In “heteroepitaxy,” the impinging atoms form the artificial crystal layer and even the same as the atoms of the substrate. In the case of heteroepitaxy, the substrate and the deposited ultrathin layer (ranging from several atomic layers to thousands of layers) have different chemical compositions. The huge research efforts put forth in improving heteroepitaxial growth over the past two to three decades already have resulted in many applications used in everyday life. These include advanced solid state detector technology (medical, solid state detectors used in medical, transport, space, and military applications, and advanced electronics “chips” used in computers, cellular phones, and other electronic devices. Nature creates many seemingly insurmountable problems in the preparation of the exotic materials used in these applications. To be useful, heteroepitaxial structures must have sharp interfaces, both between the substrates and between the various multiple layers used in advanced electronic materials. The misfit dislocation, called stacking faults, can propagate throughout the crystal and are very deleterious to the performance of the device. As the lattice mismatch between different layers, the smaller the critical thickness. For example, the mismatch between Si and GaAs, a material widely used in optoelectronic devices and fast electronic circuits, is only about 4%. In comparison, the lattice mismatch between Si and HgCdTe, the best material for infrared detection, is 19%. While the relatively small lattice mismatch between GaAs and Si allows for the growth of a useful number of monolayers before the critical thickness is reached, HgCdTe grown on Si reaches its critical thickness in only one to three monolayers. This renders its direct growth on Si useless, so that other methods for its growth have to be found. To accommodate materials with such different thermal expansion coefficients as the temperature of the heterostructure changes, the different materials expand and contract at different rates. Depending on the size of this “thermal mismatch”, new structural defects can be generated as the temperature changes.

MPL ACHIEVEMENTS IN HETEROEPITAXY

Under the leadership of Professor S. Sivrananthan, MPL has become one of the leading laboratories for the heteroepitaxy of semiconductors. The growth of CdTe and HgCdTe on Si is one of the main research topics at MPL, but many other materials are grown and analyzed as well. They include narrow- and wide-gap II-VI semiconductors, group-IV semiconductors, and metals. This ongoing work is the foundation for many important applications, which will be featured in a future issue of this newsletter. In 1989, scientists at

By Dr. Abad, Dr. Hahn, Ms. Anter, August 2004 Issue 2
The MPL has studied many other cases of heteroepitaxy and is always looking for more interesting materials. In the case of Ge on Si, the growth conditions can be tuned to grow either an array of very small Ge quantum dots or a smooth layer of Ge, which can then be used as a buffer layer for CdTe or ZnTe. On such a thin layer of Ge on Si, CdTe or ZnTe can be grown with the same crystallographic orientation as the Si substrate. This helps reduce the defect density in the CdTe layer.

The MPL has studied several cases of heteroepitaxy on CdTe on CdTe grown directly on Si. This breakthrough came after several years of research on the heteroepitaxy of CdTe on III-V substrates such as GaAs and InSb. CdTe is recognized in the semiconductor community as the best material for the detection of IR radiation, with wide applications in the defense and space industries. IR detectors made from different compositions of this material (i.e. with different Cds concentrations) are used to detect radiation at the entire IR spectral window allowed by the earth’s atmosphere. Up until 1998, most CdTe heterostructures were grown on very expensive III-V substrates such as InSb, which are limited in availability and expensive. These methods include both the demands of the new generation of IR detectors, the MPL is actively growing CdTe layers on Si substrates. In order to keep in step with the ever increasing need of the infrared device fabrication and assembly processes, the MPL has studied many other cases of heteroepitaxy and is always looking for more interesting materials. In the case of Ge on Si, the growth conditions can be tuned to grow either an array of very small Ge quantum dots or a smooth layer of Ge, which can then be used as a buffer layer for CdTe or ZnTe. On such a thin layer of Ge on Si, CdTe or ZnTe can be grown with the same crystallographic orientation as the Si substrate. This helps reduce the defect density in the CdTe layer.

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