Materials Science & Engineering Doctoral Defense

In-situ Photoemission Spectroscopy Characterization of Electronic States in Semiconductor Interfaces

School for Engineering of Matter, Transport and Energy

Xingye Wang

Advisor: Dr. Robert J. Nemanich

abstract

The electronic states of semiconductor interfaces have significant importance for semiconductor device performance, especially due to the continuing miniaturization of device technology. The application of ultra high vacuum (UHV) enables the preparation and characterization of fresh and cleaned interfaces. In a UHV environment, photoemission spectroscopy (PES) provides a non-destructive method to measure the electronic band structure, which is a crucial component of interface properties. In this dissertation, three semiconductor interfaces were studies to understand different effects on electronic states. The interfaces studied were freshly grown or pre-treated under UHV. Then in-situ PES measurements, including x-ray photoemission spectroscopy (XPS) and ultra-violet photoemission spectroscopy (UPS), were conducted to obtain electronic states information. First, the CdTe/InSb (100) heterointerface was employed as a model interface for II-VI and III-V heterojunctions. It was suggested that an interface layer formed, which consisted of In-Te bonding. The non-octal bonding between In and Te atoms has donor-like behavior, which was proposed to result in an electron accumulation layer in InSb. A type-I heterointerface was observed. Second, Cu/ZnO interfaces were studied to understand the interface bonding and the role of polarization on ZnO interfaces. It was shown that on O-face ZnO (0001) and PEALD ZnO, copper contacts had ohmic behavior. However, on Zn-face ZnO (0001), a 0.3 eV Schottky barrier height was observed. The lower than expected barrier heights were attributed to oxygen vacancies introduced by Cu-O bonding during interface formation. In addition, it is suggested that the different barrier heights on two sides of ZnO (0001) are caused by the different behavior for the ZnO (0001) faces. Last, a pulse mode deposition method was applied for P-doped diamond growth on (100) diamond surfaces. Pretreatment effects were studied. It is suggested that an O/H plasma treatment or a short period of H-plasma and CH4/H2 plasma could yield a higher growth rate. PES measurements were conducted on H-terminated intrinsic diamond surface and P-doped/intrinsic diamond (100) interfaces. It was suggested that electronic states near the valence band maximum caused Fermi level pinning effects, independent of the diamond doping.

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