380c Interface Formation and Energy Level Alignment of Pentacene on Gan

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Pentacene has recently shown to promise as a material for fabrication of organic thin-film transistors (TFTs), exhibiting high field-effect mobilities in both the single crystal and thin film morphologies. However, the performance of organic semiconductor devices such as TFTs can often be limited by the interfacial interaction of the organic material with its contact materials. We have proposed that GaN could make a favorable hole-injection contact to organic materials of high ionization potential due to its deep valence band with respect to the vacuum level. In order to evaluate this hypothesis, we studied the energy band offset of the pentacene/n GaN interface using both ultraviolet and x-ray photoelectron spectroscopies (UPS and XPS). Studies were carried out using n-GaN which was grown on a sapphire substrate by metal organic vapor phase epitaxy (MOVPE). The GaN sample was degreased with organic solvents and then treated in concentrated HCl for 15 minutes ex-situ. No additional in-situ surface treatment was performed. The photoelectron experiments were carried out in an ultra-high vacuum system with a base pressure of ~5 x 10^{-11} Torr. Pentacene was evaporated from a resistively heated boron nitride crucible in increments as small as 0.1 nm as measured using a quartz microbalance in the adjoining sample preparation chamber. UPS and XPS spectra were obtained after each deposition step to observe the evolution of the pentacene valence band structure and interfacial band bending. Our results show negligible dipole formation at the interface indicating that the pentacene/GaN interface may be accurately described using the electron affinity rule. Correspondingly, the resulting energy band offsets are in close agreement with those predicted from the individual bulk properties of pentacene and GaN, indicating that there is a small or negligible barrier for injection of holes from n-GaN into pentacene. Additional studies varied the pre-deposition treatment of the GaN surface through an initial in-situ treatment at 865 °C in 1 x 10^{-4} Torr of flowing ammonia. This surface treatment has been previously shown to produce a clean and stoichiometric surface of GaN and the results obtained using the ammonia treatment are compared with those obtained using GaN without in-situ surface treatment.