

## Experimental study of charge transport mechanisms in a hybrid metal/organic/inorganic device

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### Abstract

An hybrid metal/organic/inorganic semiconductor heterostructure was built under ultrahigh vacuum conditions (UHV) and characterized in situ. The aim was to investigate the influence of thin film layers of the organic material Dimethyl-3,4,9,10-perylenetetracarboxylic diimide (DiMe-PTCDI) on the electrical response of organic-modified Ag GaAs Schottky diodes. The device was tested by combining photoemission spectroscopy (PES) with atomic force microscopy (AFM) and electrical measurements (current-voltage I-V, capacitance-voltage C-V, impedance and charge transient spectroscopies QTS). The energy level alignment through the heterostructure was deduced. This allows us to consider electrons acting as majority carriers injected over a barrier by thermionic emission as a primary event in the charge transport. For thin organic layers (below 8 nm thickness) most of the characterization techniques show an island-like growth leading to formation of voids. The coverage of the H+ GaAs substrate as a function of the nominal thickness of DiMe-PTCDI was assessed via C-V measurements assuming a voltage independent capacitance of the organic layer. The frequency response of the device was evaluated through C-V and impedance measurements in the range 1 kHz-1 MHz. The almost independent behavior of the capacitance in the measured frequency range confirmed the assumption of a near geometrical capacitor, which was used for modeling the impedance of the device. QTS measurements performed on the heterostructure showed the presence of two relaxations induced by deposition of the organic layer. The first one is attributed to a deep trap at the metal/organic interface, while the second one has very small activation energy ( $\approx 20$  meV) which is probably due to disorder at the organic film. With such information a fit of the I-V characteristics of DiMe-PTCDI organic modified diodes based on the analytical expressions of a trapped charge limited current regime (TCLC) was intended. (Some figures are available in color only in the on-line version.) © 2007 The American Physical Society.