Paper presentation

M S Bootha Raju

Date: 28/11/09

Photoemission Spectroscopy and Atomic Force Microscopy Investigation of Vapor-Phase Codeposited Silver/Poly(3-hexylthiophene) Composites

L. Scudiero, Haoyan Wei and Hergen Eilers

Chemistry Department and Materials Science Program, Washington State University, Pullman, Washington 99163, and Applied Sciences Laboratory, Institute for Shock Physics, Washington State University, Spokane, Washington 99210

Introduction:

- The nanoengineering of hybrid polymer-metal, -metal oxide, -semiconductors – polymers and –fullerenes as thin films is a fast developing field of nanotechnology.

- Applications in novel organic optoelectronics such as solid-state electronics, electroluminescent devices and photovoltaics, and photodetectors.

- The functionality and performance of these devices are largely dependent on the charge-transfer process across the interfacial structure between organic semiconductors (polymer) and nanoparticles.

- At the hetero junction, transfer of electrons from polymer to filler (nanoparticles) will occur.

- The presence of solvent will diminish the effective interaction between filler and polymer and also charge transfer.

- Vapor phase codeposition presents an alternative route to synthesize a metal/polymer blend

In this paper,

- Poly (3-hexyl thiophene) and silver can be simultaneously thermally evaporated to form a nanocomposite, with different metal and polymer content.

- The composite materials were investigated by photoemission spectroscopy (XPS and UPS) and atomic force microscopy (AFM).

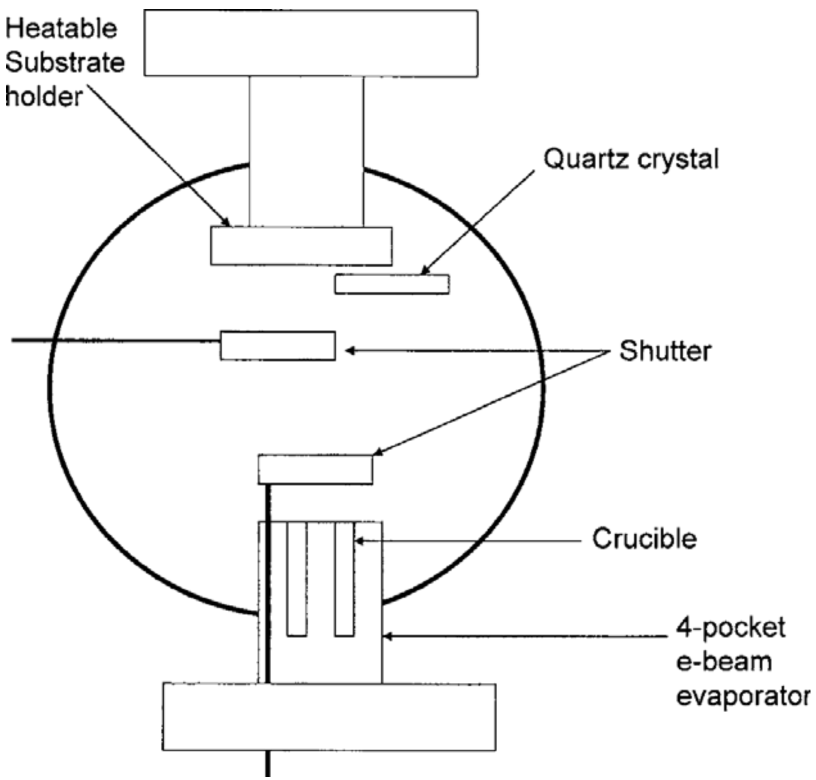
- XPS and UPS gives the electronic and chemical structure and AFM gives the morphology of the of the composites.

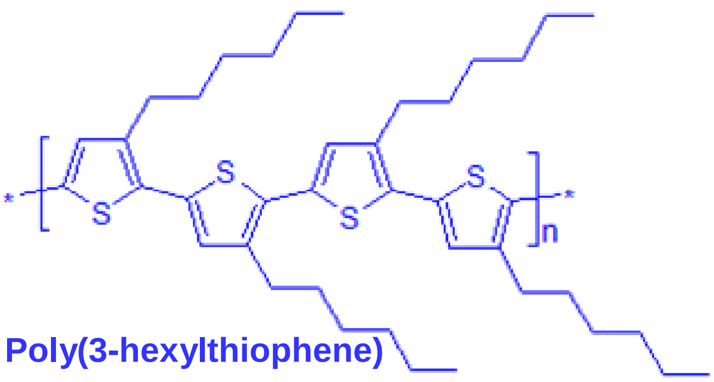
- Three nominal Ag/P3HT volume ratios were selected including 1:3, 1:1, and 3:1.

Experimental Section:

- The P3HT deposition was kept at a constant low deposition rate (ca. 1 Å/min) and the silver deposition rate was varied to alter the metal loadings.

- The thickness for all samples is estimated to be around 50 nm.





Poly(3-hexylthiophene)

Biswas *et al.* Appl. Phys. Lett. **88**, 013103 2006

Results and Discussion:

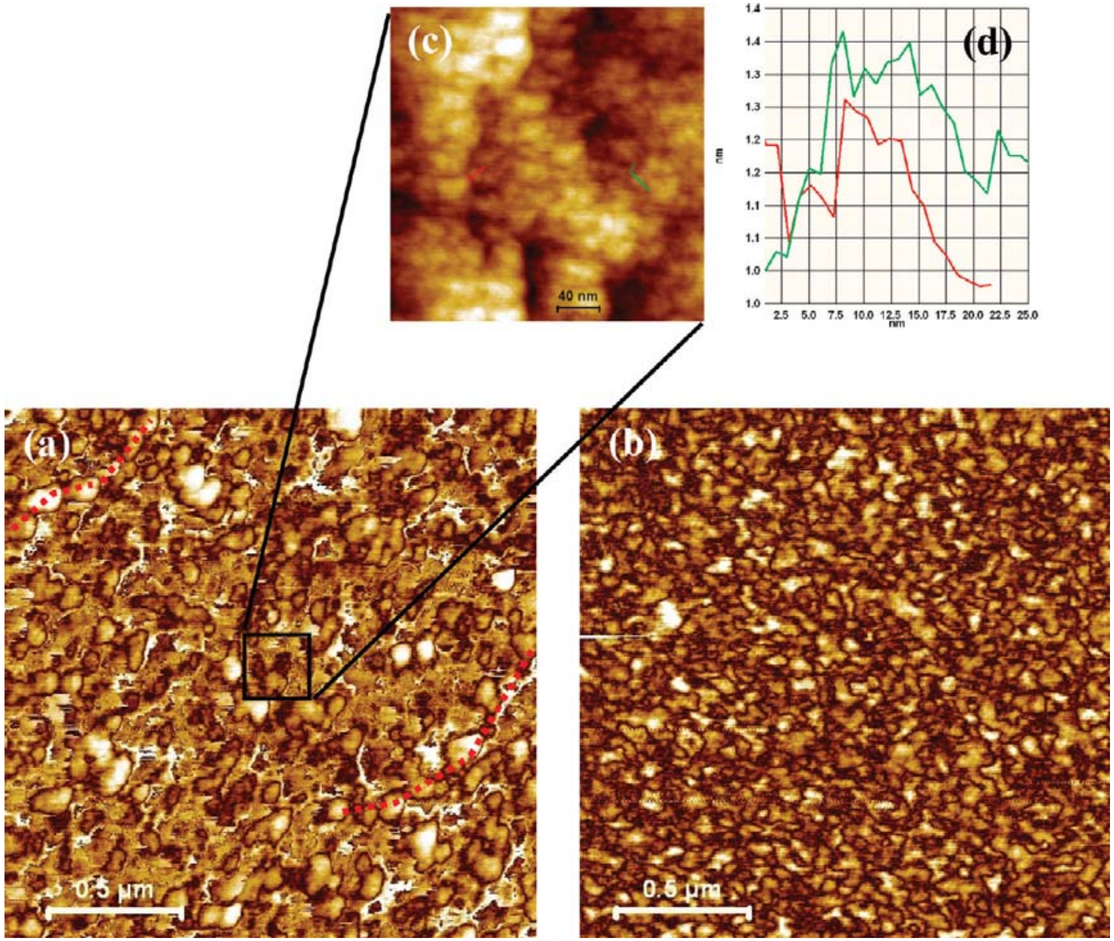


FIGURE 1. Tapping mode AFM topological micrographs of Ag/P3HT composites on Si substrates with Ag/P3HT volume ratio of (a) 3:1 and (b) 1:3. (c) High-resolution image displays a small particle size of about 20 nm across, as confirmed by (d) the line profiles.

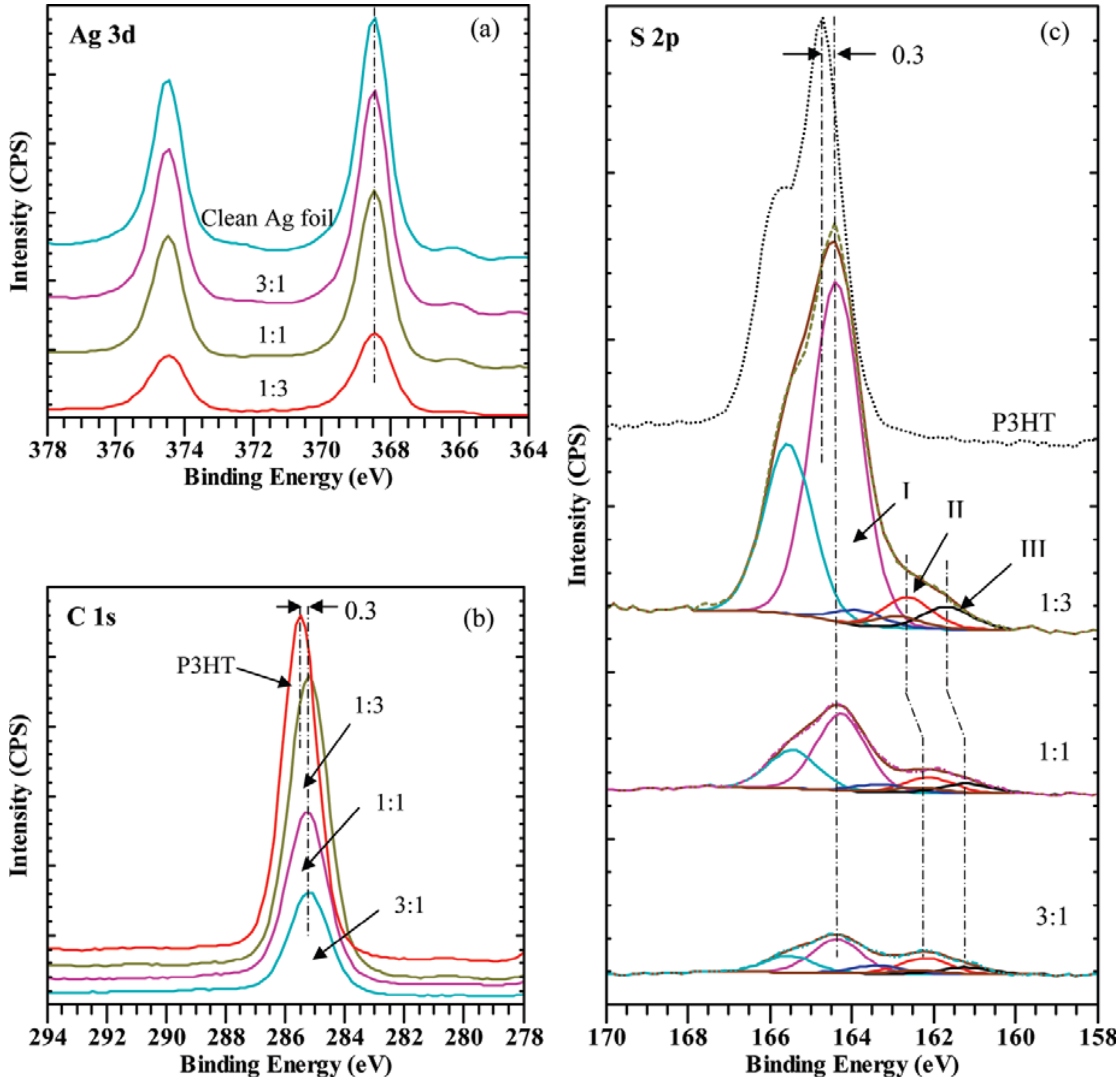


FIGURE 2. XPS spectra of codeposited Ag/P3HT matrix on Ag foil with different Ag loadings (a) Ag 3d, (b) C 1s, and (c) S 2p. The ratios represent the amount of Ag to P3HT. Spectra of vapor-phase-deposited P3HT films on Ag were also superimposed for comparison

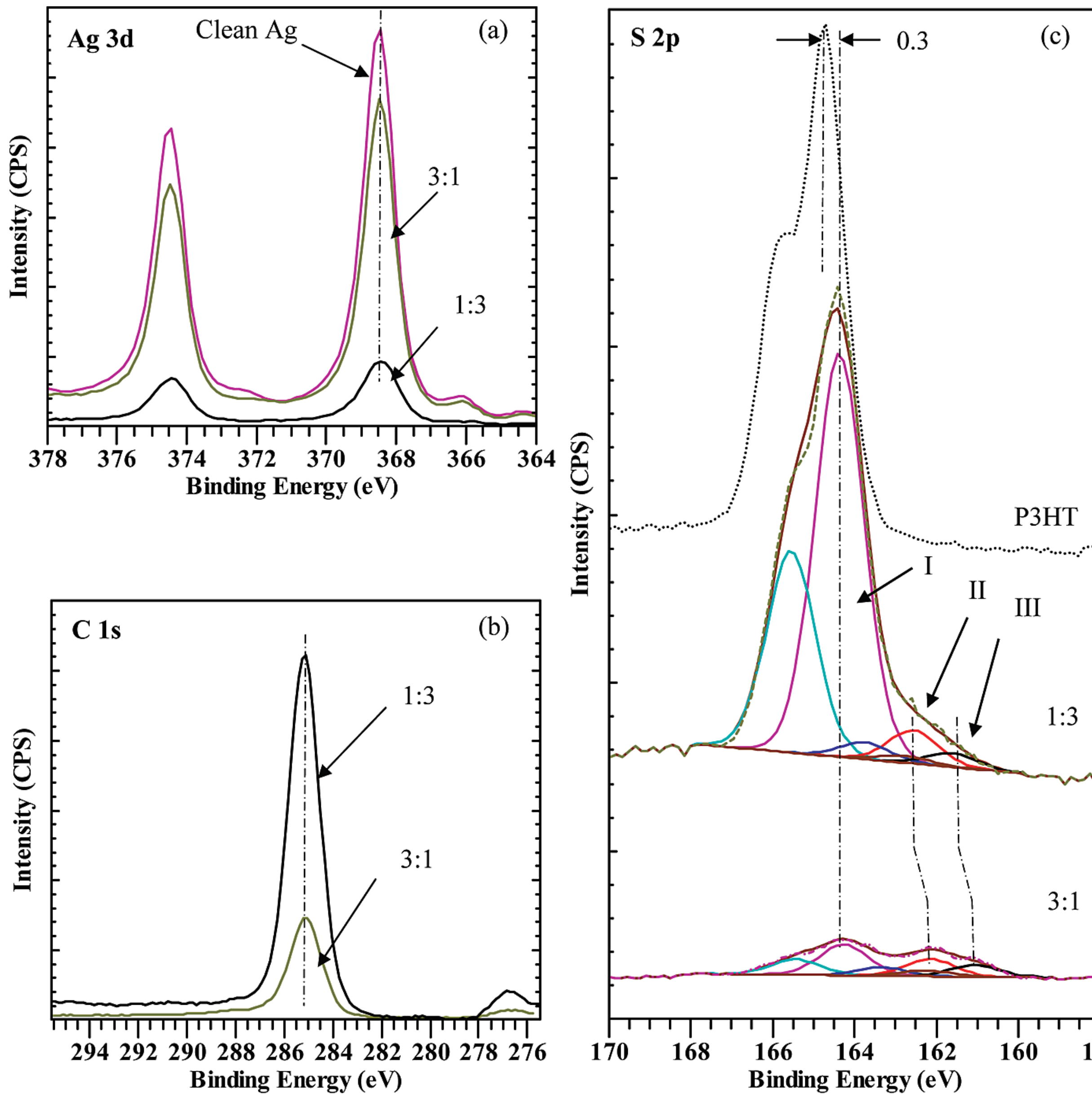


FIGURE 3. XPS spectra of codeposited Ag/P3HT matrix on silicon wafer with different Ag contents (a) Ag 3d, (b) C 1s, and (c) S 2p. The ratios indicate the amount of Ag to P3HT.

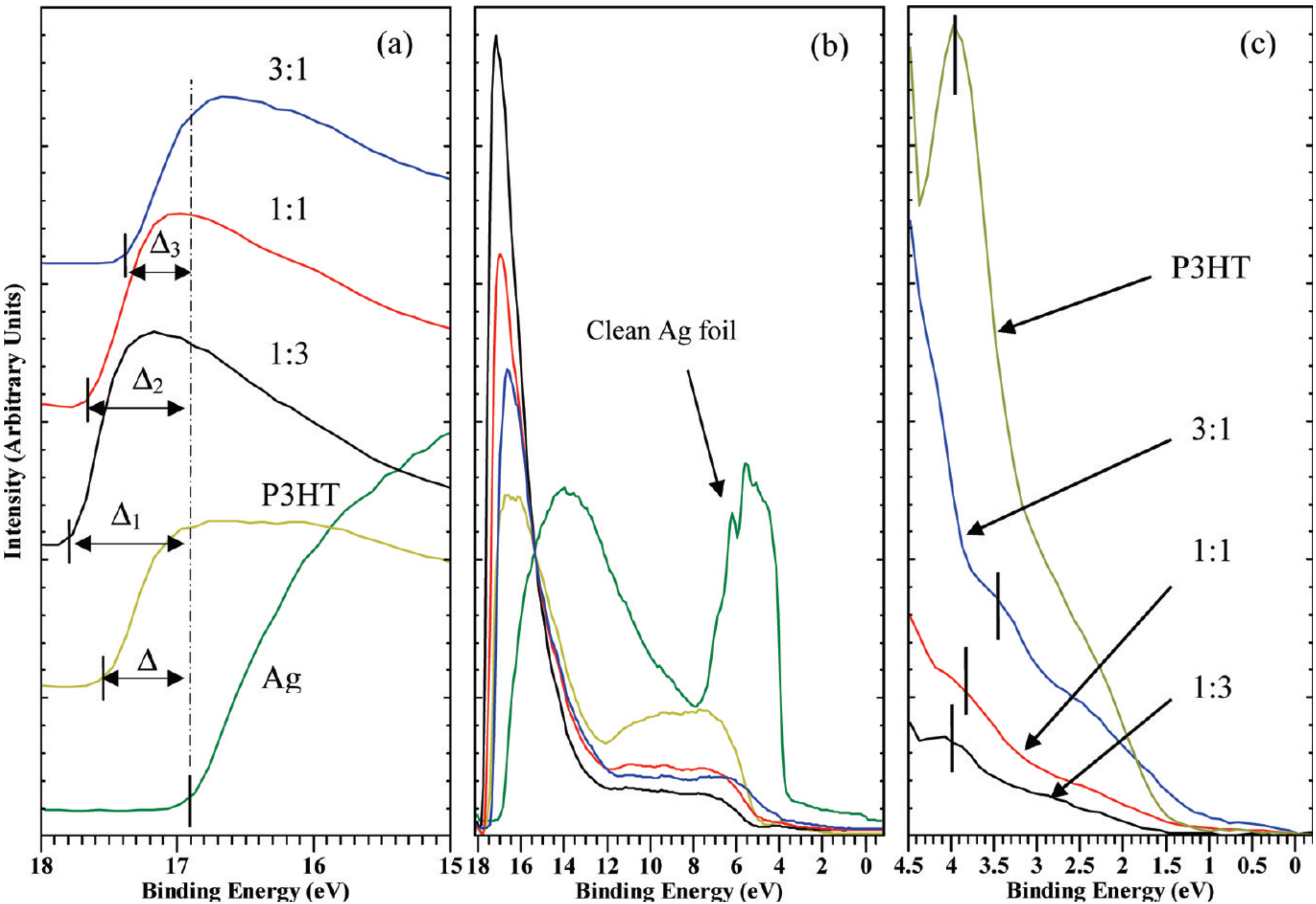


FIGURE 4. He I UPS spectra of codeposited Ag/P3HT matrix on Ag foil with three different Ag contents. Vacuum shifts (Δ) and the highest occupied band edge are shown.

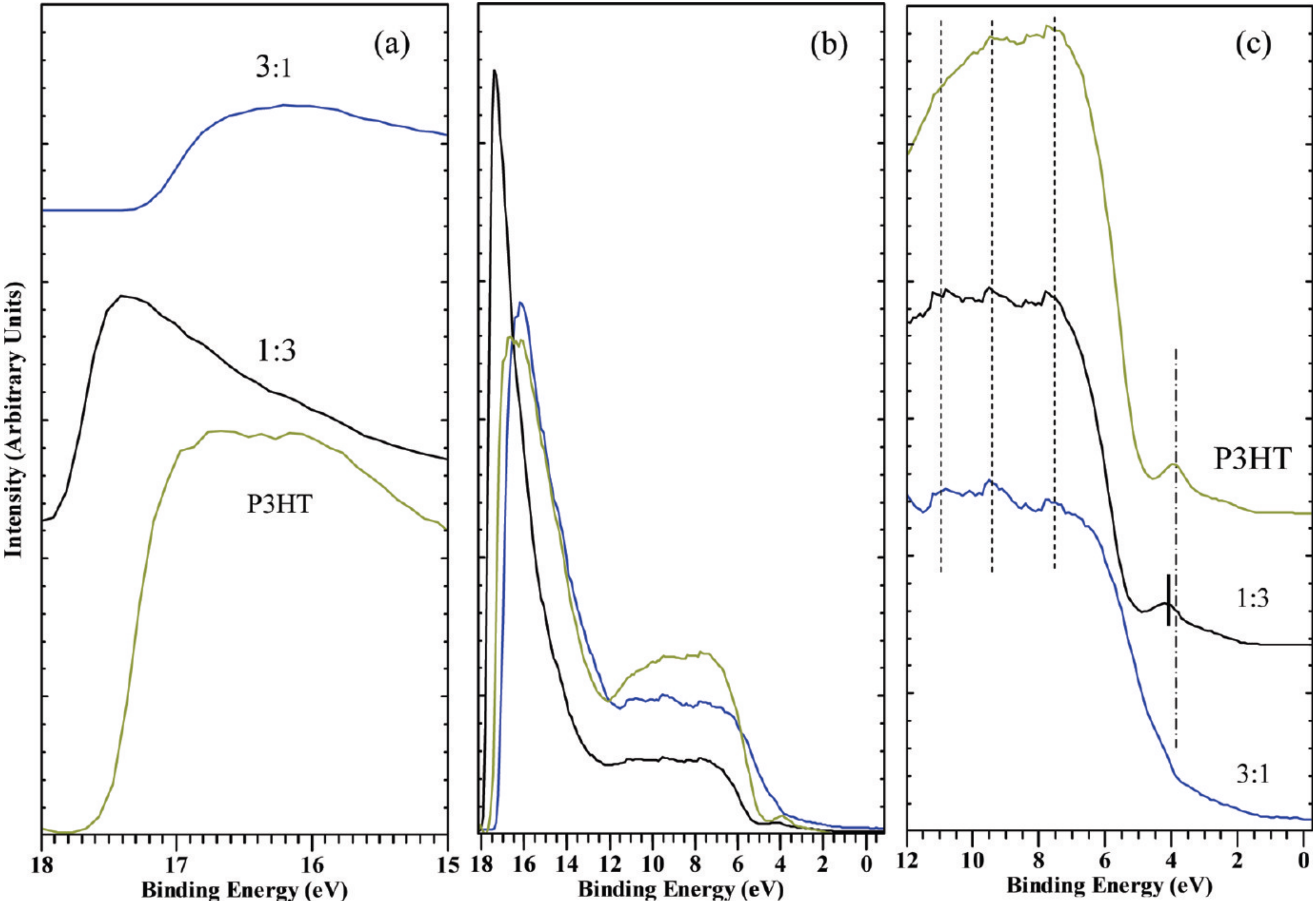


FIGURE 5. He I UPS spectra of codeposited Ag/P3HT matrix on Si coupons with two different Ag contents. Vacuum shifts (Δ) and highest occupied band edges are shown.

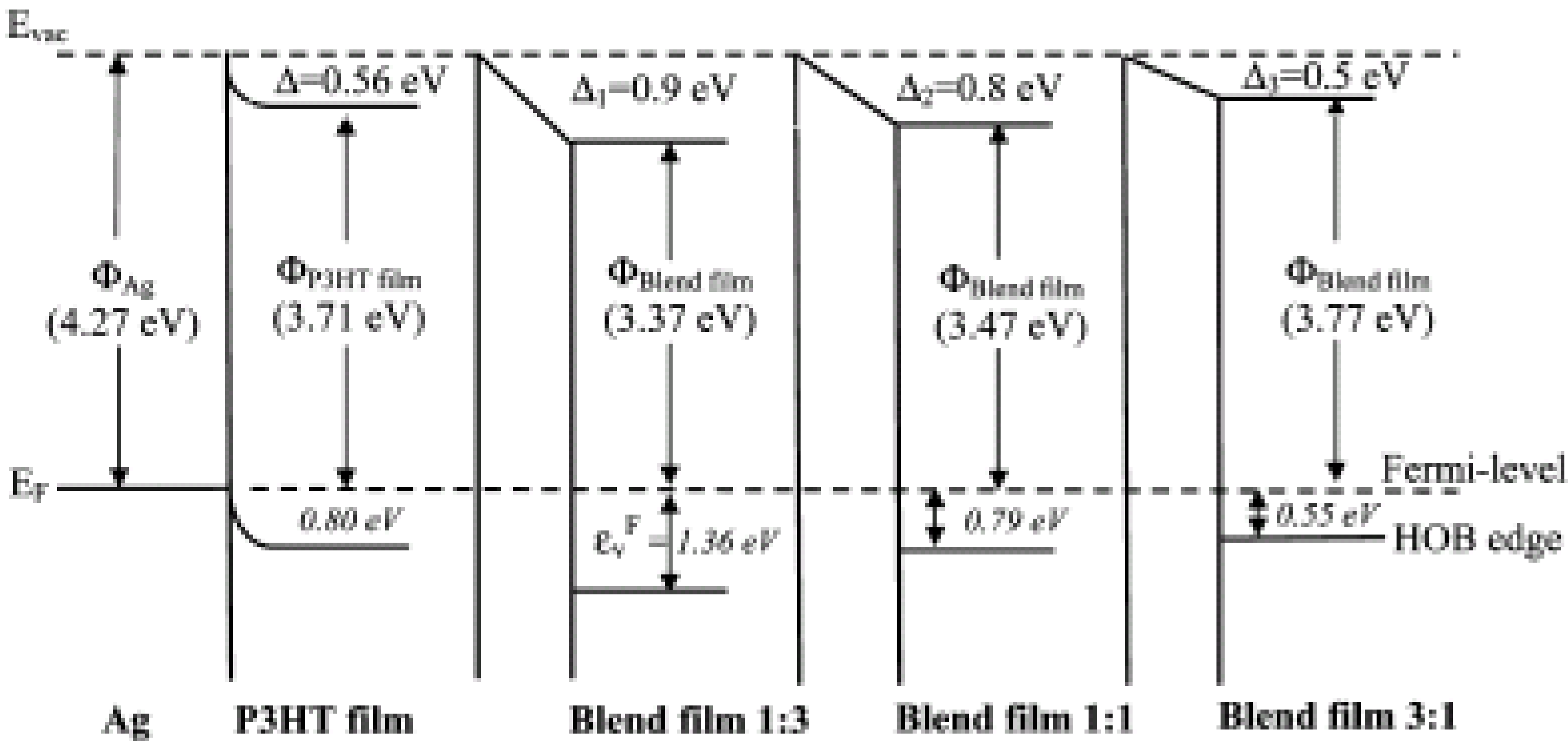


FIGURE 6. Schematic energy diagram of Ag, P3HT, and Ag/P3HT nanocomposites as a function of Ag content with respect to bulk silver. The energy information for the blend film is from the Ag/P3HT mixture rather than the interface with the underlying substrate.

CONCLUSION

- AFM showed Ag nanoparticles embedded in P3HT matrix

- XPS suggest the two Ag-S species

- UPS: Large secondary cutoff edge shifts (Δ) to higher binding energies were observed with increasing P3HT content.

- The magnitude of HOB edge (barrier height) increases with polymer content which impedes the charge injection from the Fermi energy of Ag into the valence band of the composite materials.

- Three small yet clear peaks were observed in the 5-12 eV region which is related to the σ states of P3HT backbone.

- It is possible to tune the value of the barrier height (ε^F_V) from 0.55 to 1.36 eV by simply varying the composition of the blend film (Ag/P3HT ratios).

Thanks