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Asphaltene thin films: ellipsometric view

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Asphaltenes are the heaviest and most aromatic components of crude oil. They are infusible, have no defined melting point, but decompose when heated, leaving a carbonaceous residue. Structural units of asphaltene composed of 6 to 13 aromatic rings exhibit band gap from 4.92 to 6.49 eV for the molecular fragments and from 2.84 to 3.20 eV for the free radical form what attests this material as an amorphous organic broadband semiconductor. The asphaltene has nanomolecular structure with molecular diameter within the range of 12-24Å. Therefore thin films of this material are attractive for the nanoelectronic and optoelectronic device applications.

Asphaltene films of 100-500 nm thicknesses were deposited on soda lime glass (SLG) substrates from toluene solution by pyrolysis method. The ellipsometric measurements in 220-1700 nm spectral range were performed using Woollam M2000 (USA) rotating compensator instrument. Incident light angles were varied between 50 and 60° with 5° step. WVASE32 computer program was used for the ellipsometric data fitting procedure. Experimental data were fitted (employing the Levenberg–Marquardt algorithm) to optical model using parameterized model dielectric functions simultaneously for all the data points measured in UV/VIS ranges. Surface roughness/ asphaltene/SLG three-phase model was used for fitting the data. Surface roughness has been modelled using Bruggeman effective medium approximation with 50 % voids.

Imaginary part of dielectric function which is the electronic density of states shows two type of optical transitions: peak at ~290 nm (~ 4.3 eV) and start of optical transitions at 410 nm (~ 3.0 eV) corresponding to the minimum optical gap that coincides with the peak position in the photoluminescence excitation spectra of the studied asphaltene films. The latter gap can obviously be attributed to the band gap of the film which is mainly in free radical form. These results are in good agreement with the results obtained for asphaltene solution.

Keywords: Asphaltene, thin film, spectroscopic ellipsometry, dielectric function, band gap