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Preparation and Properties of Colorless Polyimide/Clay Nanocomposite Films for Flexible Substrate

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Polyimide/clay nanocomposites for flexible colorless substrates were prepared from the solution of poly (amide acid) and organically modified-montmorillonites(OMMTs) using N,N-dimethylacetamide as a solvent. Poly(amide acid) was prepared from the reaction of 2,2'-bis-(3,4-dicarboxyphenyl)Hexafluoro-propane dianhydride(6FDA) and 2,2'-bis(trifluoromethyl)-4,4'-diaminophenyl(TFDB). Polyimide(PI) is used largely for microelectronics. However it would be desirable to reduce the coefficient of thermal expansion (CTE), amount of moisture absorption and gas permeability, because those properties of PI are not sufficient for advanced electronics use. Montmorillonite(MMT) consists of stacked silicate sheet about 2000 Å in length, 10 Å in thickness. It has a low CTE and a high gas and water barrier property (MMT is dispersed homogeneously into PI matrix and oriented parallel to the film surface). Owing to this special structure of clay, the defects of PI are improved. As clay contents increase, PI/clay nanocomposites show better properties than pristine PI. However the transparency of the PI/clay nanocomposite films are reduced a little.

precursor ((EtO)₂Si(CH₃)₃).¹¹ These films have low dielectric constants and good mechanical stability. Yu et al.^{12a} and de Theije et al.^{12b} reported the synthesis of mesoporous low dielectric constant organo-PI films containing SiO₂R^{'''} (R^{'''} = -CH₃, -N=C=O) in a silica and polymer matrix. These mesoporous organosilica films were placed onto solid substrates such as silicon wafers or glass slides using spin- or dip-coating methods. Three groups¹³ have reported the synthesis of PI/C₁₂-MMT(0.5wt%) mesoporous PI/C₁₂PPh-MMT(0.5wt%) water interface. Recently, we described a surfactant-templated synthesis of high-quality free-standing and oriented PMO films grown at the air-water interface.¹⁴ To the best of our knowledge, however, no work has been reported on the synthesis of mesoporous organosilica film with controllable pore size without a solid substrate grown at the air-water interface. In this paper, we report the first synthesis of PI/C₁₂-MMT(2wt%) mesoporous PI/C₁₂PPh-MMT(2wt%) and

Transparency of PI and PI/OMMT nanocomposite films with various OMMT contents.

Substrate	Avg. Transmission(%) (400nm – 700nm)	Sheet Resistance (Ω /sq.)	Figure of merit FTC(x 10 ⁻³ Ω -1)	Figure of merit Φ TC(x 10 ⁻³ Ω -1)
Fluorinated PI	79	119.36	6.61	0.79
PI/C ₁₂ -MMT 0.5wt%	77	96	8.02	0.76
PI/C ₁₂ -MMT 1wt%	76	77.18	9.85	0.83
PI/C ₁₂ -MMT 2wt%	75.4	40.09	18.81	1.48
PI/C ₁₂ PPh-MMT 0.5wt%	76	76.86	9.89	0.84
PI/C ₁₂ PPh-MMT 1wt%	75.7	44.46	17.0	1.39
PI/C ₁₂ PPh-MMT 2wt%	73.5	38.55	19.1	1.19
Glass	85.9	24.47	35.1	8.93
Commercial ITO	83	9.28	89.4	16.7
ITO PI*	76.9	19.8	38.8	3.65

* H. Lim et. al, Adv. Mater., 18,14(2002)

The sheet resistance, figure of merit and average transmittance of the ZnO:Al films deposited on Corning 1737 glass and PI substrates at $T_s = 200$ °C