Transparent Nano Clay-Polyimide Hybrid Technology for Flexible Display

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Introduction

Adding nano clay in polyimide can promote the material, especially thermal stable property. Traditional clay/polyimide processes were two approaches. The first, clay was modified to an organoclay by ion exchange with quaternary ammonium compounds to improve dispersibility in an organic solvent. The organoclay was then mixed with a polymer material in the organic solvent to provide a composite. The composite thus prepared has an inorganic content of up to 20wt%. The second, the clay was intercalated with a water soluble polymer to improve dispersibility, and then dispersed in a polymer matrix. The composite prepared by this approach had a high inorganic content of 30wt% or above. However, both of the two approaches involve the dispersion of clay in an organic matrix, and therefore when inorganic content was increased, the material will inevitably become opaque and brittle due to insufficient polymer content. Now we provide a process[Scheme 1] different from the traditional, clay was modified to H-form clay and then solvent transfer from water to organic solvent. Finally the well dispersion clay sol was added into polyimide solution directly. The clay/polyimide solution reacted enough time and then coated on glass and dried in oven and then get a transparent film.

Results and Discussion

[Sheet 1] shows the CTE of several inorganic content of clay/polyimide hybrid films. The high inorganic content of silica/polyimide indeed reduced the CTE value. If 40% clay added, the CTE reduced to 24.7 ppm/□. Even 50% clay added, the CTE was under 10 ppm/□ but several samples has some brittle. The over 50% clay/polyimide stable will investigate in the future. The light transmittances of 40% clay/polyimide hybrid films were measured by UV-VIS spectrometer as shown in [Figure 2]. The light transmittances of the hybrid films was 94.62% at 550nm. It means that the clay was dispersed well in the 40% clay/polyimide hybrid films. The chemical resistant of flexible substrate is the key to develop the TFT on it. The chemical resistant test results of 40% clay/polyimide were recorded in [Sheet 2]. The chemical agents used in the TFT process were photo resistant, developer, Oxalic acid and stripper. The 40% clay/polyimide was coated on the glass and dried in the air oven and then dropped the agents on it and into the oven again. Fortunately 40% clay/polyimide can pass all agents treatment. The clay was dispersed well in the matrix and the content of clay in the hybrid film was very high. For getting the most correct microstructure of clay in the matrix, the 3D tomography analysis of the 40% clay/polyimide was done. The 3D tomography was performed to further observe the sample direction distribution of inorganic filler [Figure 3]. Clay in the matrix was network structure.

Conclusions

The clay/polyimide has many advantages for flexible products, especially the thermal property and chemical resistance. It was attributed to the highly clay content hybrid technology. The newly developed nano-clay/polyimide film can withstand high temperature(300 ~ 350℃) and chemical processing as general μ-Si TFT fabrication in industry.

Reference

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Scheme 1. Clay dispersion and clay/polyimide hybrid process.

Clay	CTE (ppm/℃)
0%	> 60
20%	40.3
30%	38.3
35%	34.8
40%	24.7
50%	8.6

Sheet 1. Coefficient of thermal expansion(CTE) of clay/polyimide reduces with increasing percentage of clay.

Figure 1. clay/PI 40/60 solution and film.

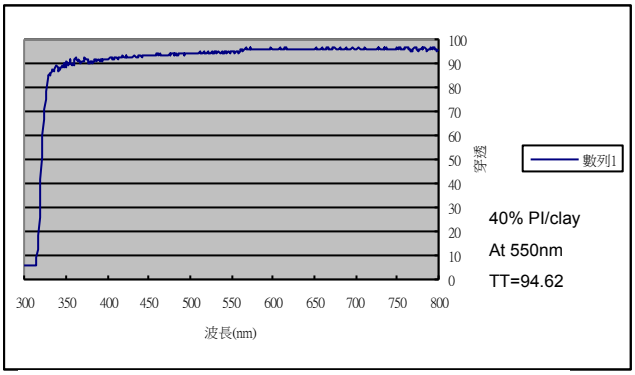

Figure 2. UV/Vis spectra of clay/PI 40/60 film. At 550nm, the TT is 94.62%.

immersed, @50℃, 1hr	PI	PI/clay
Photo-resist(AZ650)	O	O
Developer (38% (aq) *TMAH*)	O	O
Oxalic acid	O	O
Stripper（NMP）	X	O

Sheet 2. Chemical Resistance test of clay/PI film, the four agents are usually used in display manufacture.

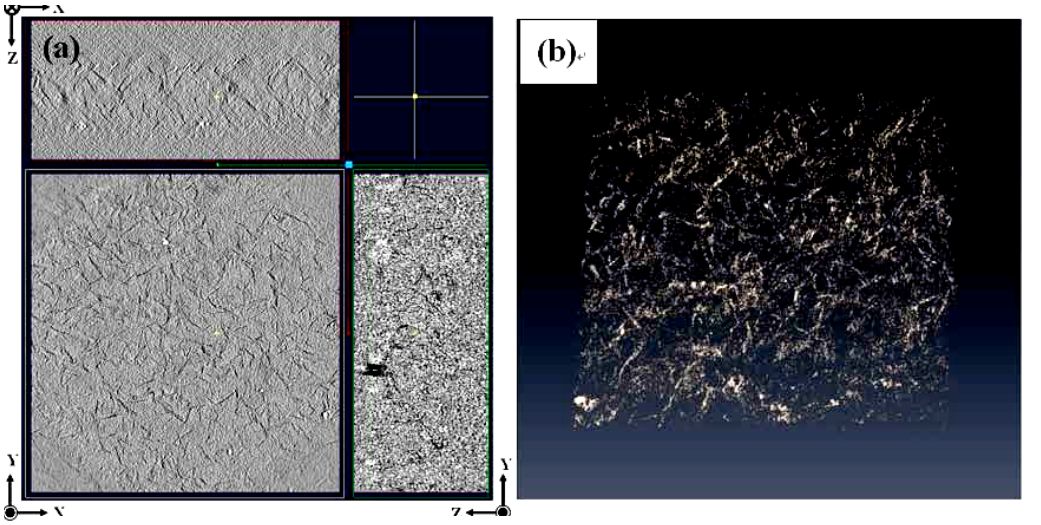

Figure 3. TEM photography of clay/PI 40/60 film. (a) X, Y, Z axis scan. (b) We can see the connection of clay.