# Plastic Substrate for Flexible Display

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## Abstracts

*A plastic substrate for flexible display is developed. The gas barrier and optical properties of the substrate is improved through depositing silicon oxide/nitride layer and coating polymer layer on plastic film by sputtering process and wet coating process. Roll to roll processes will guarantee the productivity in the whole production process of the plastic substrate.*

## Introduction

The researches and developments on plastic based flat panel displays have been widely advanced[1,2]. The customer driven factors into the flexible display market include reduced weight, reduced thickness, good resistance to breakage, compatibility of roll to roll process, and lower cost.

There are some serious issues in fabricating flat panel display using a plastic substrate. First, the mechanical stability of plastic substrate must be ensured in panel fabrication process. The problems of mechanical stability include heat resistance, dimensional stability in each process. Second, the performance of plastic display must be equivalent to that of conventional displays. The optical birefringence, transmission, and gas barrier property of plastic substrate should satisfy requirements of substrate for flat panel display[3,4,5].

We focused on gas barrier property, optical transmittance and productivity of plastic substrate in this work. For gas barrier property, inorganic layers show effective results. And an anti-reflection coating layer should be used on inorganic layer to ensure high optical property. We report organic coating layer made by wet coating process to increase the productivity. Selectively chosen polymer layers are used to warrant anti-reflection condition.

## Results & Discussion

We produced the PES film having a superior resistance to heat and excellent optical properties such as optical retardation, transmittance, haze, and yellow index. The optical transmittance was 88% at 550 nm, retardation below 8 nm, haze below 0.3 %, yellow index below 2.5, and surface roughness below 5 nm of 200 um PES film.

An inorganic layer was deposited for effective gas barrier layer. We used silicon oxide or silicon nitride material as gas barrier material. The silicon oxide layer has good optical transmittance but showed inferior gas barrier property. The silicon nitride layer shows excellent gas barrier property but inferior optical transmittance[6]. Therefore we try coat organic layer of low refractive index compared to the inorganic layer on silicon nitride layer. The common thickness is 15-20nm for silicon oxide and silicon nitride. The UV polymerisable urethane acrylate is used as top coating layer. The refractive index of the acrylate polymer is about 1.5. The polymer layer on silicon nitride film increases optical transmittance of barrier film.(Figure 1) The polymer coated plastic substrate shows excellent scratch resistance and solvent resistance. Table 1 shows the physical properties of the inorganic coated PES film and the polymer coated barrier film.

The gas barrier property of developed plastic substrate is about 0.01 $g/m^2/day$ and optical transmittance is 90%

## Conclusion

We use roll to roll process in whole production process-film extrusion, PVD process, and wet coating process. Roll to roll processes make it possible to produce lower cost plastic substrate. The mass-production of plastic substrate has allowed us to approach commercialization of flexible plastic displays. We improved the performance of plastic substrate to satisfy the requirements of plastic substrate for TFT-LCD in many ways.

New plastic substrate we developed shows strong possibility to commercialize various flexible displays such as electronic paper, plastic LCD, flexible organic light emitting display.

## Acknowledgements

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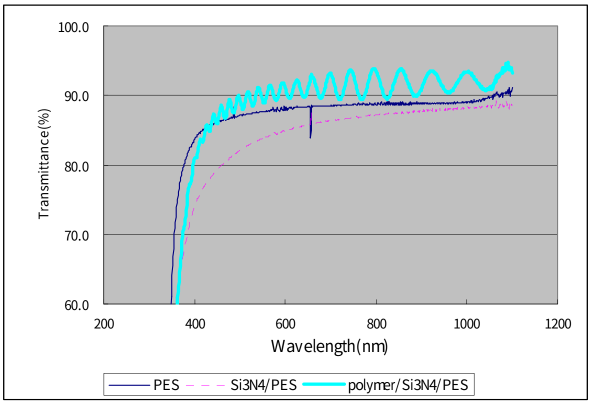


Figure 1. Optical transmittance spectrum of polymer coated barrier film

| Items | Unit | Conditions | $SiO_2$/PES | $Si_3N_4$/PES | polymer/$Si_3N_4$/PES |
|---|---|---|---|---|---|
| Light Transmittance | % | 430/550/630 nm | 87.87/89.50/89.54 | 79.49/84.52/85.97 | 85.96/89.94/91.14 |
| YI | | | 1.46 | 5.30 | 3.84 |
| Haze | % | | 0.29 | 0.30 | 0.12 |
| Film retardation | nm | | 3.7 | 5.0 | 2.7 |
| Scratch resistance | | | Bad | Bad | moderate |
| Water Vapor Transmission Rate | $g/(m^2 day)$ | Temp 37.8℃, RH 100%, 24h | 2.3 | 0.5 | ~0.01 |
| Oxygen Transmission Rate | $cc/(m^2 day)$ | Temp 35℃, $O_2$ 100%, 24h | - | - | ~0.01 |
| Thermal stability | R1/R0 | 180℃, 30min | - | - | 0.74 |
| Chemical resistance | R1/R0 | Soaking 10min NMP solvent | ∞ | ∞ | 1.25 |

Table 1. Physical properties of inorganic coated PES films and polymer coated barrier film (R1: WVTR of treated sample, R0: WVTR of non-treated sample)