Ultra thin glass roll for flexible AMOLED display

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ABSTRACT

Ultra thin glass roll, 50 microns thick, 800mm wide and over 100m of long, has been successfully produced. The roll has high flexibility, smooth surface, high thermal stability and excellent impermeability to gases. The roll is useful for flexible AMOLED display driven by amorphous oxide TFTs.

1. INTRODUCTION

1.1 Background

The flexible display has been much anticipated as a new display device which opens up a new market. Many electronics companies are actively researching technologies in this field, especially , such as liquid crystal display (LCD) and organic light emitting diodes (OLEDs).

Since LCD requires a precise cell gap between two substrates to guarantee a quality of image, it would be hard to control the cell gap when the LCD panel is bent.

AMOLED has the advantages of fast motion picture response time, vivid color, high contrast, compact structure and lightweight.

The challenges of AMOLED are large size image uniformity and reliability, which are strongly affected by TFT technology. Although a-Si TFT shows good uniformity, electron mobility is not sufficient. On the other hand, p-Si TFT shows higher electron mobility, but uniformity throughout a large area is not sufficient [1].

An amorphous oxide semiconductor, a-$InGaZnO_4$ (a-IGZO), facilitates flexible and transparent TFTs with much improved performance. Compared to conventional a-Si TFTs, the TFTs show higher mobility and uniform performance over large areas [1, 2]. Thus, it is thought that AMOLED driven by amorphous oxide TFTs is suitable for the flexible display.

1.2 Requirements for substrate

The following substrate properties are required for flexible display manufacturing.

Thermal stability - In order to obtain high performance TFTs, display fabrication requires thermal treatment over 400° C [3]. The flexible substrate must have thermally stable dimensions.

Gas barrier – impermeability is important to guarantee the OLED performance. OLED quality is deteriorated by H_2O or O_2 gas.

Smooth surface- a continuous even surface is important for fine patterning.

Flexibility- this property is essential not only for flexible displays but also for roll-to-roll process.

2. Properties of Ultra thin glass roll

Ultra thin glass roll, developed by Nippon Electric glass, is a promising material for substrates for flexible display. In this section the properties of the ultra thin glass roll will be discussed.

2-1 Size of Ultra thin glass roll

Figure 1 is an ultra thin glass roll. Thickness and width of the thin glass are 50 micron and 800mm, respectively. Ultra thin glass roll over 100m has been successfully rolled. We believe this glass roll can be applied to the roll-to-roll process. This ultra thin glass is produced by an overflow down draw method.

Figure 1 A photo of ultra thin glass roll.

2-2 Surface state of the glass

Figure 2 is a schematic of the overflow down draw process. The great advantage of the process is that glass with ultra smooth surfaces can be obtained without a polishing process. The surfaces of molten glass do not make contact with any other material during the forming process.

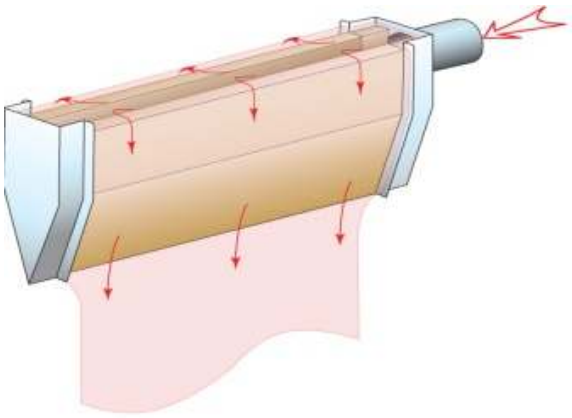

Figure 2 Schematic of overflow down draw forming process.

The AFM images in Figure 3 and Figure 4 are a glass surface formed by the overflow down draw method and polished surface respectively. The surface roughness (Ra) of Figure 3 of unpolished thin glass is around 0.1-0.2nm, which is lower than that of polished glass surface.

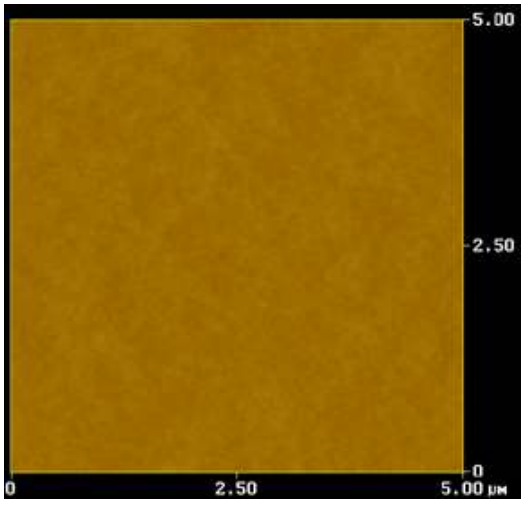

Figure 3 AFM image of a glass surface formed by the overflow down draw method.

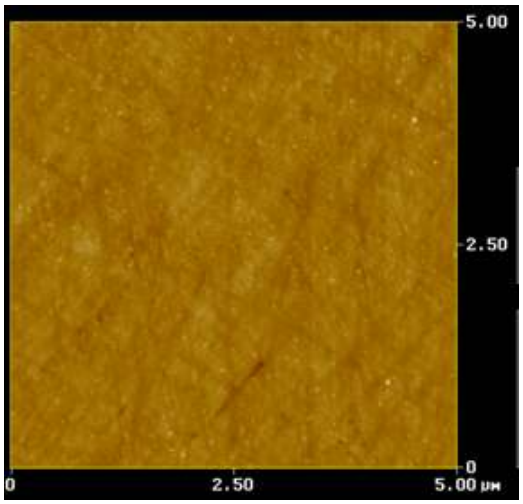

Figure 4 AFM image of a glass surface polished with cerium oxide.

2-3 Properties of the thin glass

The glass code of the thin glass roll is OA-10G. This glass has been widely used as substrate for LCD.

The properties of OA-10G are listed in Table 1.The strain point of OA-10G is 650 ° C. This temperature is high enough to withstand heat treatment temperatures used in the production process of amorphous oxide TFT.

Table 1 Properties of OA-10G

	OA-10G
Density [g/cm^3]	2.46
Thermal expansion coefficient [×10^{-7}/° C] (30-380° C)	38
Strain point [° C]	650
Young's modulus [GPa]	73
Poisson's ratio [-]	0.2
Transmittance(λ=550nm) [%]	92
Refractive Index(nd) [-]	1.52
Volume resistivity at 350° C [Ω・cm]	12
Permittivity (1MHz・25° C) [-]	5.3
tan δ (1MHz・25° C) [-]	0.001

2-4 Minimum core diameter of the thin glass roll

The relationship between the bending curvature and the resultant stress induced is shown in Figure 5. In general, the average breaking stress of glass is around 100-200MPa. However, the breaking stress can be degraded by edge condition. Taking the safety range of the breaking stress of the glass into consideration, if the safety limit of breaking stress is assumed to be 50MPa, thin glass of 50micron thickness can be rolled at a radius of 40mm.

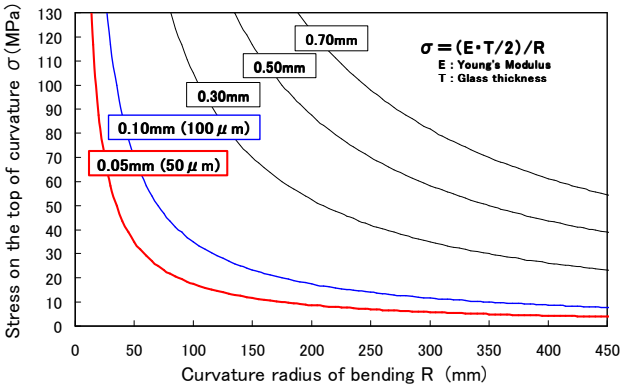

Figure 5. Stress at the top of curvature versus curvature radius of thin glass.

2-5 Gas permeability of the thin glass

The permeability of 30 micron ultra thin glass to H_2O or O_2 gas can not be detected by the API-MS method (Sumika Chemical Analysis Service). This ultra thin 30-micron glass was a specially produced glass for this gas permeability test. The lower limits for H_2O and O_2 gas are $<7 \times 10^{-7}$ g / m^2 day (85° C, 85%RH)and $< 8 \times 10^{-3}$ cc / m^2 day, (40 ° C, 90%RH) respectively. The results indicate that the ultra thin glass shows excellent impermeability to H_2O and O_2 gas, even though the thickness is only 30 microns. This is believed to be the first data on the gas barrier properties of ultra thin glass.

3. Summary

Ultra thin glass roll has been successfully produced by Nippon Electric Glass. The glass roll exhibits attractive features: flexibility, smooth surfaces, impermeability to gas and thermal stability. These features are quite useful for obtaining high quality and reliable TFT performance.

We believe the introduction of ultra thin glass roll will establish a new standard of performance for flexible AMOLED display.

4. References

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[3] Toshio Kamiya, Kenji Nomura and Hideo Hosono “Impact of subgap states on peculiar characteristics of Amorphous oxide thin-film transistor” Proc. IDW ’09, pp. 1673-1676 (2009).