High thermal stability glass substrate for high resolution display

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ABSTRACT

A new glass substrate “OA-30” has been developed. The high strain point of OA-30 leads to reduced thermal shrinkage of glass substrates during thermal treatment in the Low temperature poly-silicon (LTPS) TFT process. Low thermal shrinkage of OA-30 contributes to the realization of high resolution displays with LTPS TFTs.

1. INTRODUCTION

High resolution displays have been widely used for mobile devices. LTPS is the most suitable TFT for displays due to its high electron mobility. Since the process temperature of LTPS TFT is higher than that of a-Si TFT, conventional glass sometimes causes a patterning mismatch from its thermal shrinkage. As the weight of the display for mobile devices needs to be lighter than that for TV’s and monitors, thinner and lighter substrates are required. However, thinner glass substrate occasionally causes breakage in the process due to its gravity sag, which would be a critical issue of lowering the productivity of the devices.

2. Properties of OA-30

The properties of OA-30 are shown in Table 1, compared with conventional the LCD glass substrates, OA-11 and OA-10G [1]. The characteristics of OA-30 are a high strain point and a high Young’s modulus. The high strain point and Young’s modulus realize high thermal and mechanical stability. Typical characteristics of glass are described as follows.

Table 1. Properties of OA-30, OA-11 and OA-10G.

Properties / glass code		unit	OA-30	OA-11	OA-10G
Density		g/cm^3	2.62	2.52	2.46
Thermal expansion coefficient (30-380°C)		$\times 10^{-7}/K$	39	37	38
Strain point		°C	740	685	650
Thermal shrinkage	500°C 60min	ppm	15	30	60
	600°C 60min		60	170	360
Young's modulus		GPa	81	78	73
Specific modulus		$GPa/(g/cm^3)$	30.9	31.0	29.7
Poisson's ratio			0.2	0.2	0.2
Volume resistivity (350°C)		Ω·cm	12.0	13.0	12.0
Dielectric constant (1MHz, RT)			5.9	5.6	5.3
tanδ (1MHz, RT)			0.002	0.001	0.001
Refractive index (nd:587.6nm)			1.53	1.53	1.52
Alkali contents		wt%	<0.1	<0.1	<0.1

3. Thermal stability

Figure 1 shows a schematic illustration of the measurement method for thermal shrinkage [2]. Marking lines were made by patterned Cr film. A glass sample with marking lines was separated along the long side into two pieces by laser scribing. One piece was subjected to heat-treatment (Figure 2). After heat-treatment, the treated piece was placed in touch with the untreated one. The displacements of each marking line were measured and then shrinkage was calculated by using the following equation:

Shrinkage [ppm] = (Δl_1 [μm] + Δl_2 [μm]) / l_0 [m] .

Here, l_0 is the length between marking lines before heat-treatment. Δl_1 and Δl_2 are the displacements of each marking line.

Figure 3 shows thermal shrinkage of OA-30, OA-11 and OA-10G after heat-treatment at 400-600°C for 60 min. The thermal shrinkage of OA-30 is less than 1/4 of that of OA-10G at 500°C and 1/6 of that of OA-10G at 600°C. This comes from the high strain point of OA-30. The result shows that OA-30 is much more stable in dimension at high temperature, which is suitable for the LTPS process.

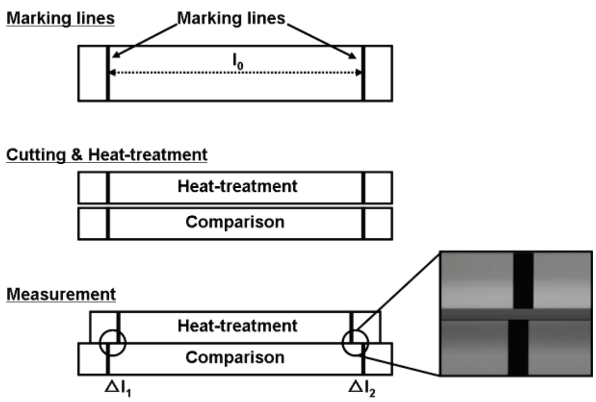

Figure 1. Schematic illustration of the measurement method for thermal shrinkage.

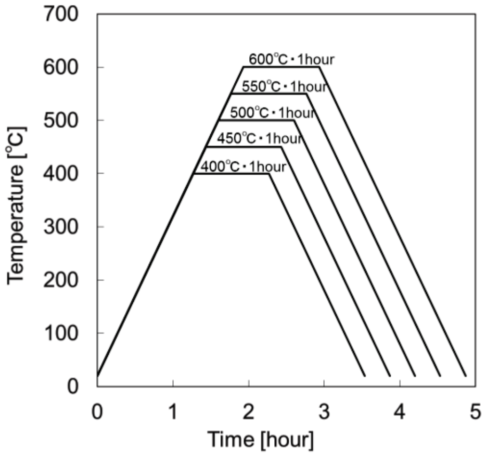

Figure 2. Profile of heat treatment for measurement of thermal shrinkage.

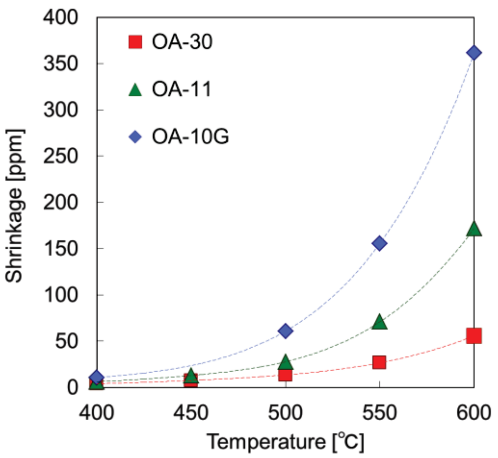

Figure 3. Thermal shrinkage of OA-30, OA-11 and OA-10G heat-treated at 400-600°C for an hour.

4. Mechanical stability

Table 2 shows the calculated gravity sag of OA-30, OA-11 and OA-10G along the thickness. The gravity sag of the glass substrate is calculated by using the equation in Figure 4, which indicates that the sag decreases with increasing specific modulus, that is, the ratio of Young's modulus to density (Young's modulus / density). The sag of OA-30 and OA-11 are lower than that of OA-10G. The lower sag is achieved because of the high specific modulus of OA-30 and OA-11. OA-30 and OA-11 exhibit a small gravity sag. As glass size is increased or thickness is decreased to meet the demand of LCD panels, the gravity sag of the glass substrate increases. If the gravity sag is too large, the risk of glass substrate fractures increases during transportation. So OA-30 and OA-11 are expected to increase device productivity by decreasing the risk of glass breakage.

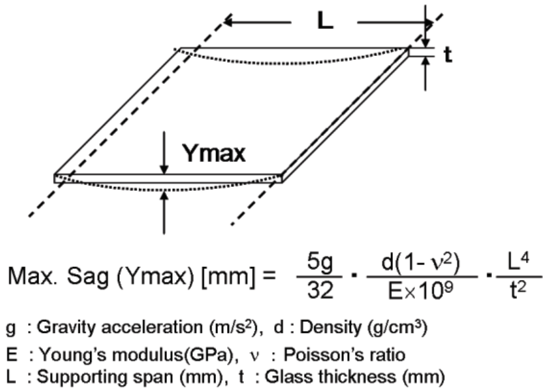

Figure 4. Gravity sag for glass substrate.

Table 2. Calculated gravity sags of OA-30, OA-11 and OA-10G along thickness of glass substrate.

Glass code		OA-30	OA-11	OA-10G
Specific modulus [GPa/g/cm^3]		30.9	31.0	29.7
Thickness [mm]	Span [mm]	Sag [mm] (calculation values)		
0.7	500	6.1	6.1	6.3
0.5	500	11.9	11.9	12.4
0.4	500	18.6	18.6	19.4
0.3	500	33.0	33.0	34.3

5. SUMMARY

Newly developed OA-30 would be a promising substrate for LTPS process due to its high thermal and mechanical stability.

The high thermal stability realizes precise patterning at LTPS process requiring high temperature heat-treatment. The high mechanical stability would reduce the risk of breakage of glass substrate in the LCD manufacturing process.

6. REFERENCES

[1] Takahiro Kawaguchi et. al., IDW'09, pp.827-830.
[2] Tomoki Yanase et. al., IDW'08, pp.1837-1840.