Substrates for Flexible AM Displays

Technical Information

TIP 503
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Supercedes: xxxxx

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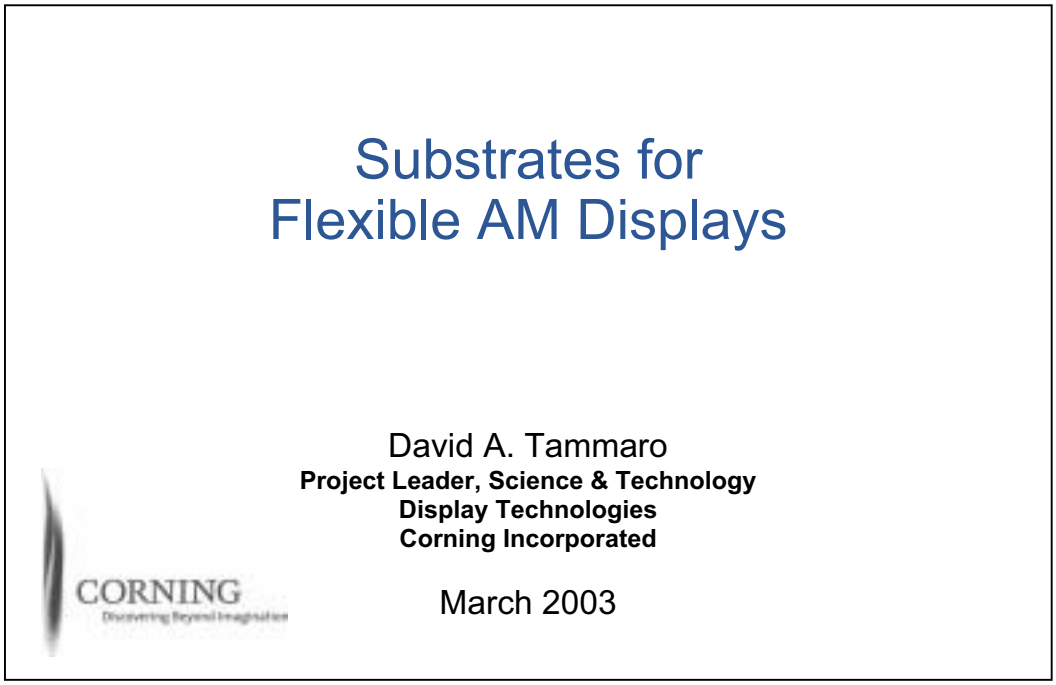

Agenda

- Glass Substrates in AMLCD
- Dispelling Myths about Glass Substrates
  - Myth #1: Glass is Not Flexible
  - Myth #2: Thin Glass = Weak Glass
  - Myth #3: Substrate Attributes Don't Matter
- Corning's Future in Flexible Active Matrix Displays
- Conclusion

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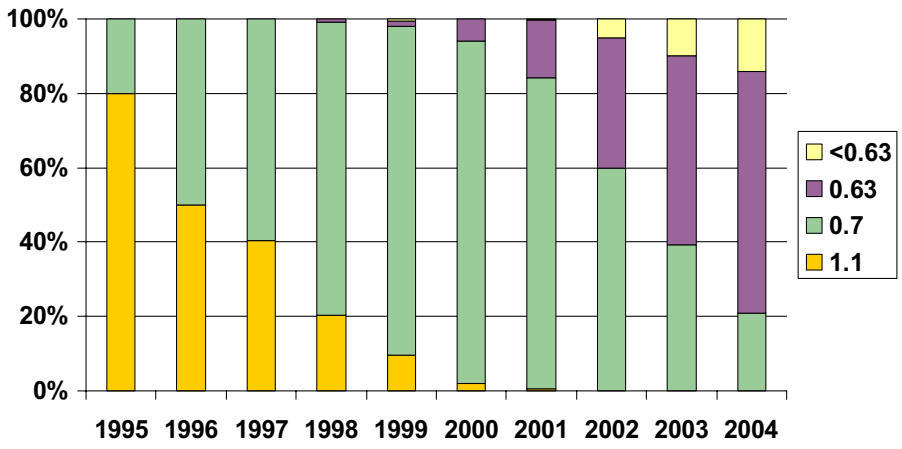
Glass Substrates are Getting Thinner



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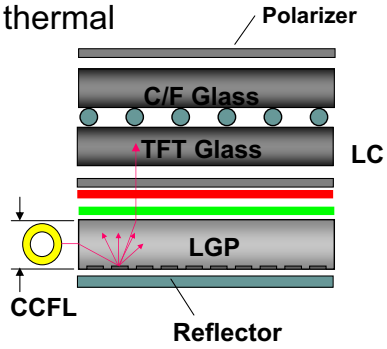
Drivers for Thin Glass in AMLCD

- Improved visual appearance of display
- Lighter weight displays
- Thinner form factor
- Potential for higher throughput in thermal processes

- Challenges:
  - sag
  - vibration
  - panel cutting and edge finishing



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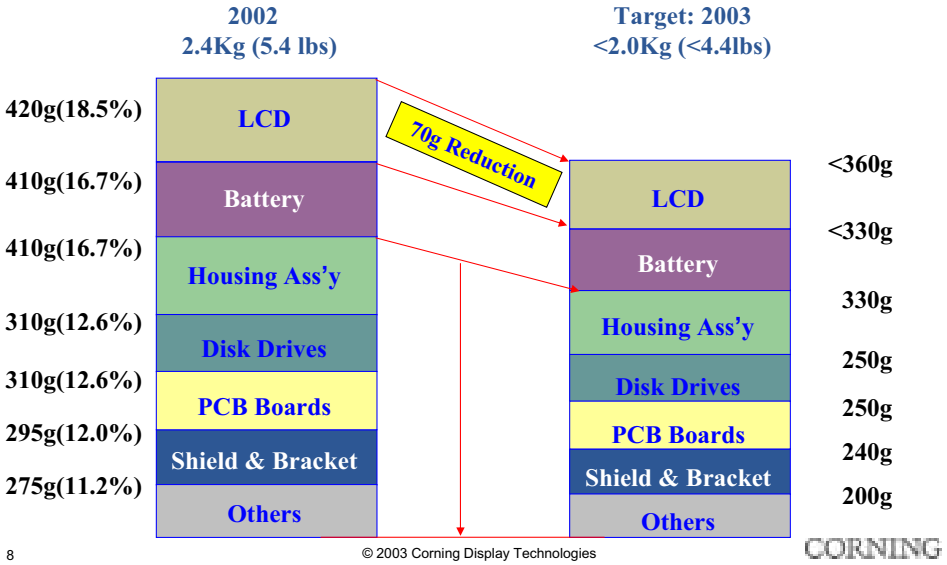
14.1" Notebook PC Weight Target: Input from 2 Display Makers-



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Flexible Displays Using Conventional AMLCD Processing Require Two Innovations

A. Thin Substrates

Handling Innovations+

1. Thin Glass

Property Improvements+

2. High Performance Polymers
   or Multilayer Materials

+

B. Backlight Assembly

1. Emissive Technology (OLED)
2. Thin Film Backlights.
3. Reflective Technologies

=

C. Thin & Flexible
Active Matrix Displays

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Myth #1: **Glass is not Flexible**

Would you have guessed glass is *This Flexible*?

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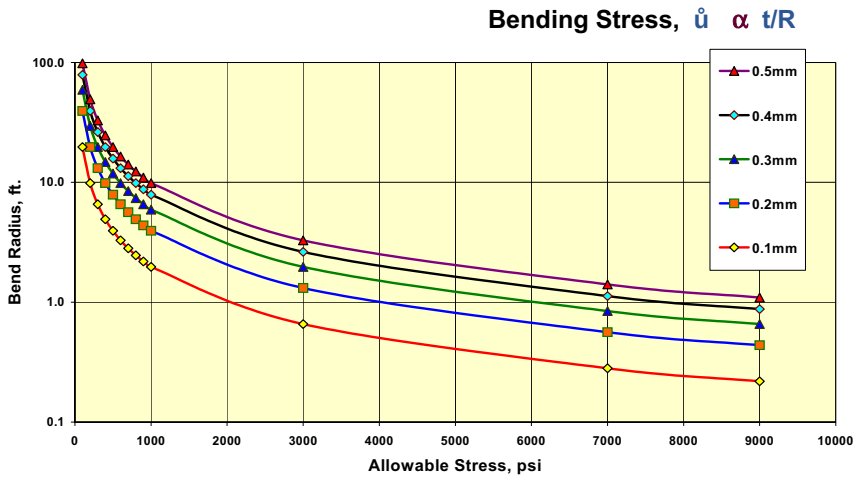
Glass Thickness and Bend Radius



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Myth #2: **Thin Glass = Weak Glass**

Glass Strength is an *Extrinsic* Property

Affected By:

- Surface Quality
- Impact Area (Test Area)
- Stress Rate
- Environmental Conditions (Test Environment)

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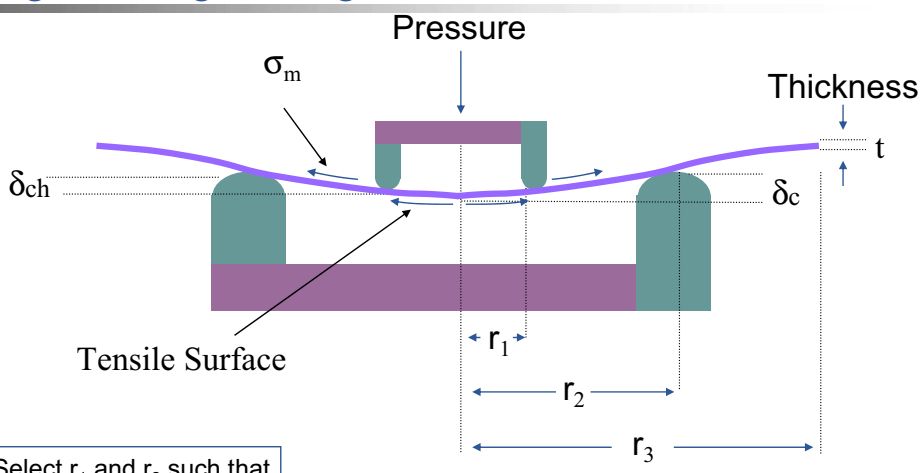
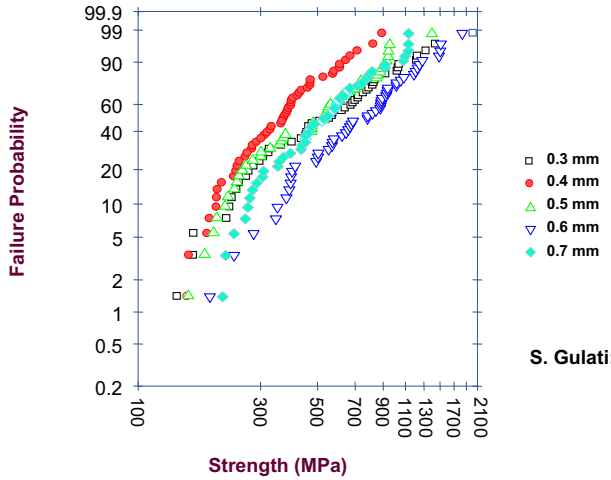
Ring on Ring Strength Test



Select r_1 and r_2 such that
(a) $\delta_c < t/2$
(b) $\sigma_m << \sigma_b$

Glass Strength - Weibull Distribution

Plate stress from ROR testing of as-received LCD glass

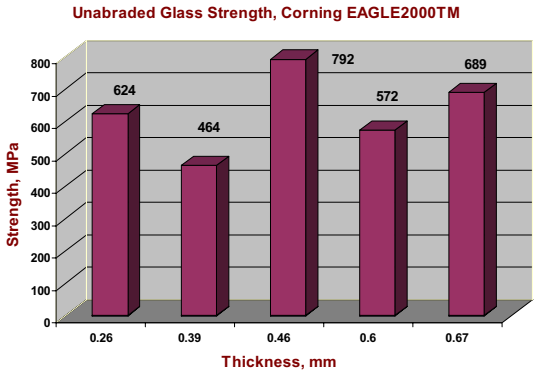


S. Gulati: SID, '02

Glass Strength is Independent of Thickness

Glass Breakage is controlled by surface flaws and applied stress

- Thinner edge
  - more concentrated contact
- Less mass
  - less force at contact



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Myth #3: Substrate Attributes Don't Matter

Substrates are NOT Created Equal –

Active Matrix Displays Require Substrates with:

- High Dimensional Stability
- High Chemical Durability
- Low Gas Permeation
- Good Optical Performance
- Flat, Clean Surface for Precision Patterning

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Substrate Properties are Driven by AMLCD Manufacturing Paradigm

- Horizontal Handling (flexibility = sag)
- Single Sheet Processing Advantages
  - Defect control
  - Selects (Crash = single substrate loss)
- Ultra Clean Surfaces
  - <1 particle/1000cm^2 /pass, PECVD
  - High Quality
  - Good Interfaces
- High Process Temperatures
  - a-Si: 300-450 ^{o}C
  - p-Si: 450 -600 ^{o}C

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Comparison of Flexible Substrate Properties

Attribute	EAGLE^{2000TM} For TFTLCD	PET	PC Teijin SS120-B60	Appear^{TM} 3000	AryLite^{TM} A 100HC	Sumilite® PES FST-X014
Density (g/cm^3)	2.36	1.4	1.19	1.16	1.22	1.37
Tg (^{o}C)	725	69	155	330	325	223
CTE ppm/^{o}C (-55 to 85^{o}C)	3	20	70	74	53	54
Water Absorption (%)	0	-	0.3	0.03	0.40	1.4
Refractive Index (633 nm)	1.45	1.66	1.58	1.52	1.64	1.65
%Transmission (400-700nm)	>90	94	91 w/o ITO	91.6	90.4	90.1
Birefringence (nm)	<0.1	<10	<1	<10	<10	<10

1. Appear3000, PES/SumiLite, AryLite100H data from www.go-plastics.com
2. PET, PC data from "Plastic LCD's Material Technology and Low Temperature Process, p. 129, 1st Ed. Mar. 29, 2002.

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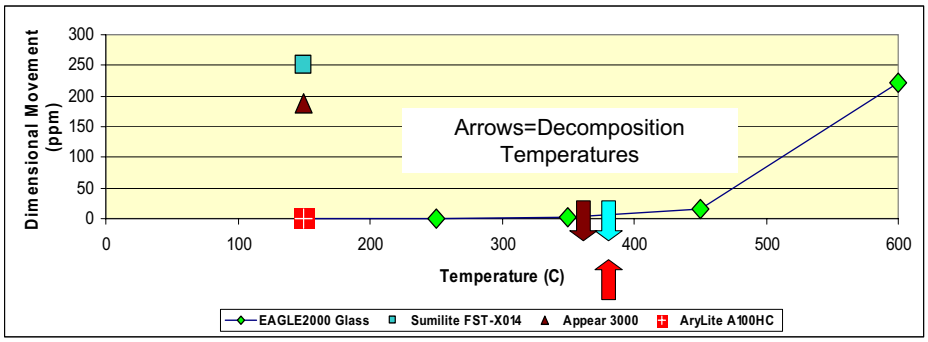
Compaction Results



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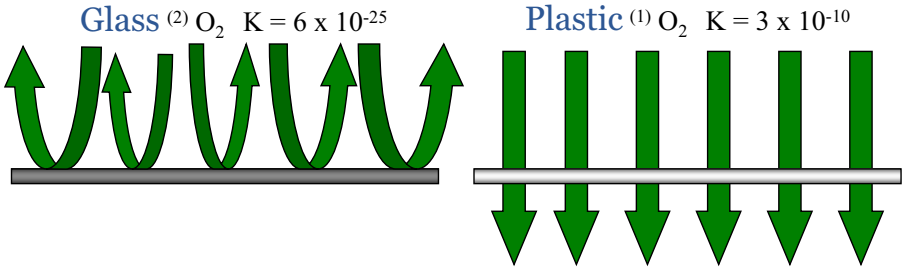
O_2 and H_2O Permeation are Major Issues in OLED Lifetime.

Consider the Oxygen Permeation issue:

- Key polymer limitation for plastic/OLED lifetime.
- 30 microns glass = 14 million kilometers of PET (oxygen).



1. Kline, G.M., Modern Plastics, p. 139, March, 1966.
2. Extrapolated from: Norton, Nature, p.191, August 1961.
3. K, Units = [cm3(STP)x mm]/[sec x cm2 x cm.Hg]

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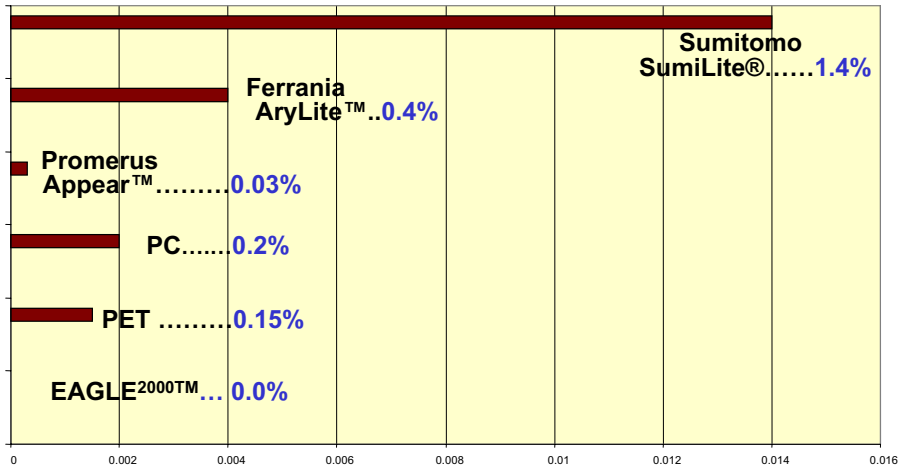
Weight Change upon Exposure to Water



1. LCD Glass test conditions = 24 hours, 95 ^{0}C.
2. Polymer data from go-plastics.com, and matweb.com

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Flexible Substrate Issues in High Performance Display Manufacturing

	Density	Mechanical Handling	Dimensional Stability			Optical Performance		Permeation	Chemical Durability
			Tg	CTE	H2O Abs.	UV Degrade	Birefringence		
Polymer	●	●	●	●	●	●	●	●	●
EAGLE 2000™	●	●	●	●	●	●	●	●	●

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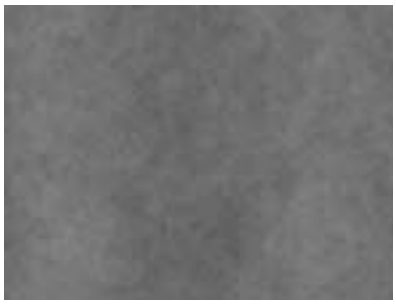
The Corning Fusion Process Advantage: Flat, Clean Surface for Precision Patterning

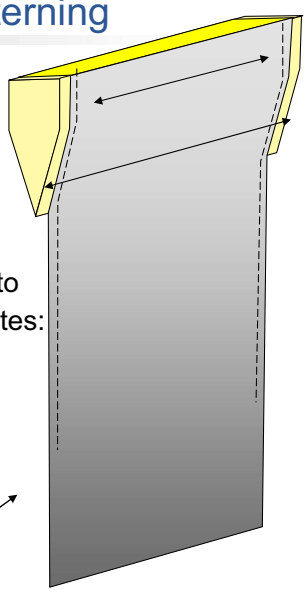
Fusion-forming is ideal for producing smooth surfaces….



EAGLE^{2000TM} AFM, Ra=0.2nm

Surface quality is *not* affected by the shift to thin & flexible substrates:

- ultra flat
- pristine, clean



Thickness from >1.1 to <0.3

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Commercialization of Very Thin Glass (<0.4mm) Brings a Number of Development Challenges.

- Handling
  - Protect surface and edges
- Finishing
  - Alternate scoring/separation techniques
  - Edge protection techniques
- Single Sheet Horizontal Transport (sag)
  - Vertical transport options
  - Alternate supporting schemes
  - Roll to roll processing

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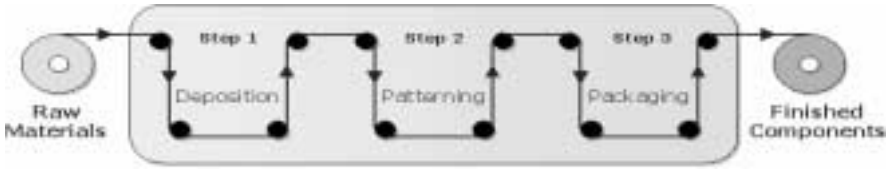
Technical Challenges of Continuous Processing (Roll to Roll?)

- Maintaining Cleanliness
- Inter-layer Damage



Stretching During Substrate Transport

	Elongation to break	Modulus (GPa)
Polymers:	7-17%+	1-3
Glass:	0%	70

See USDC FPD Technology Roadmap Ch. 22, Mar. 2002 for polymer modulus data

See go-plastics.com for elongation data.

Image taken from www.rolltronics.com

Summary

- Flexible does NOT equal plastic.
  - Thin glass is flexible.
- Thinner glass does NOT mean weaker substrates.
- Glass attributes meet AMLCD requirements.
- It's all about the Attributes.
- For flexible high information content displays (e.g.AMLCD) thin glass is the answer.

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