Winter 1-1-2008

Lecture 7, Part 4: Glass surfaces and coatings for biotechnology - Thermochemical processing effects on multicomponent glass surfaces

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Thermochemical Processing Effects at Multicomponent Glass Surfaces

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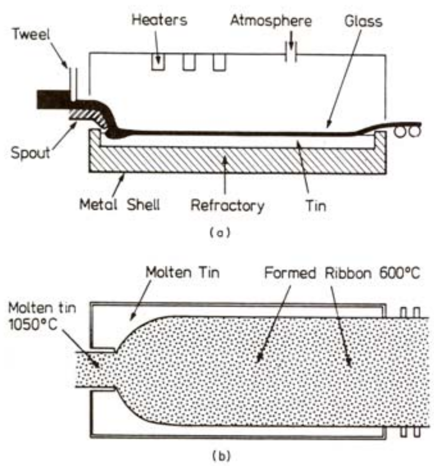
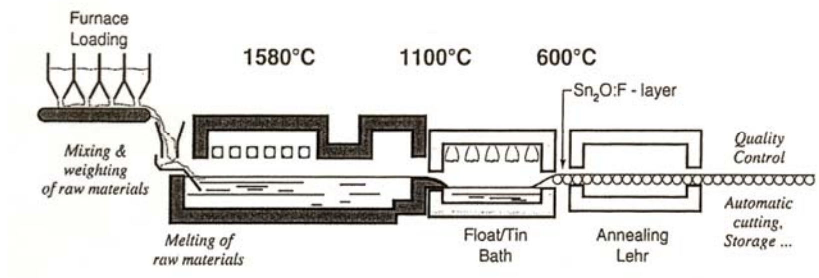
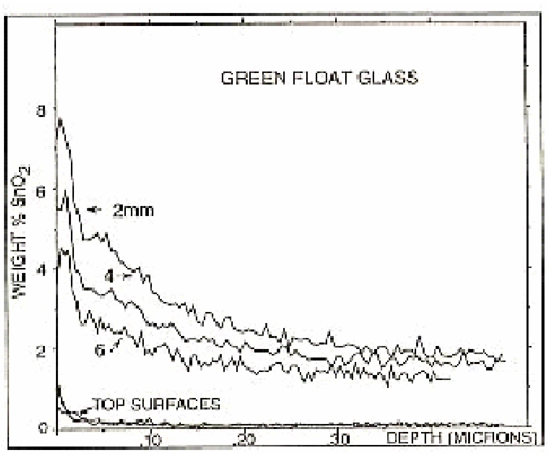


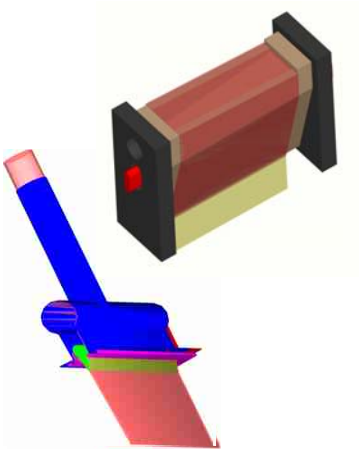
Figure 20-14. Float glass process. (a) Float bath. (b) Equilibrium mode of operation (After W. C. Hynd., in Glass Science & Tech., vol. 2, Processing I (D. R. Uhlmann and N. J. Kreidle, eds.), Fig. 14. p. 86. Academic Press, New York, 1984).


Furnace
Loading
1580°C
1100°C
600°C
Sn_2O:F - layer
Mixing &
weighting
of raw materials
Quality
Control
Automatic
cutting,
Storage ...
Melting of
raw materials
Float/Tin
Bath
Annealing
Lehr


GREEN FLOAT GLASS
WEIGHT % SnO_2
2mm
4
6
TOP SURFACES
DEPTH (MICRONS)
0
2
4
6
8
10
20
30

How are flat, thin glass sheetss made?

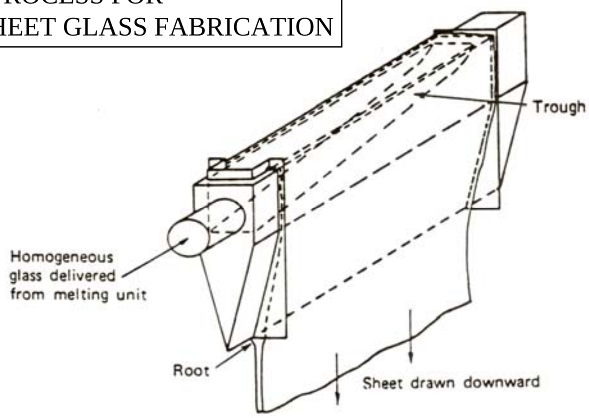
Homogenous, conditioned glass flows over a weir, downward a blade, through a nozzle, or on a spinning drum to form a film which is continuously withdrawn



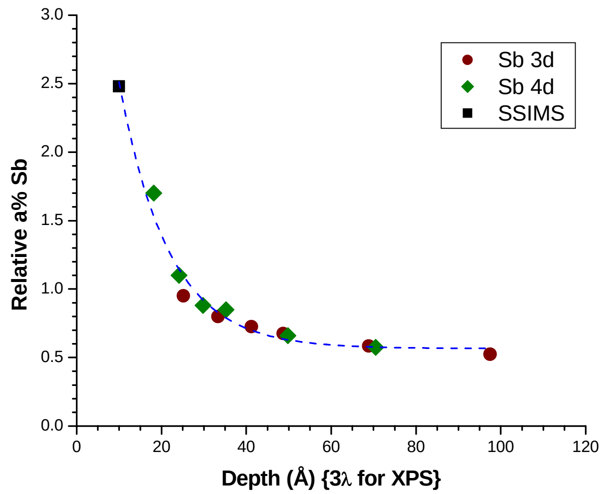
The thickness of the formed film is a function of …
- the glass viscosity
- the surface tension
- the drawing speed and flow rate

Challenges:
- Surfaces in glass contact have to be precision-machined for ultra-thin glass
- Components have to keep alignment during heat-up and during operation
- Precise temperature control needed to avoid viscosity differences which lead to thickness variations, and potentially devitrification

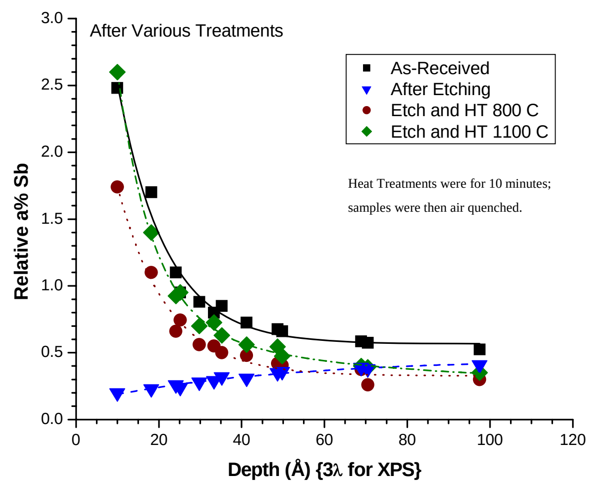
FUSION PROCESS FOR MICROSHEET GLASS FABRICATION



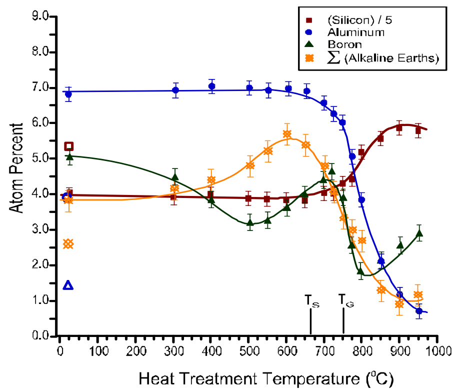
Antimony Depth Distribution by Angle-Resolved XPS and FAB-Static SIMS

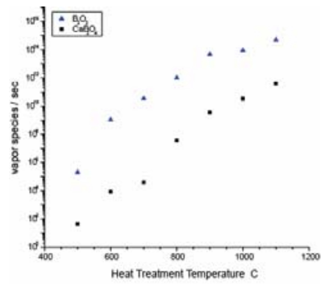


Antimony Depth Distribution by Angle-Resolved XPS and FAB-Static SIMS



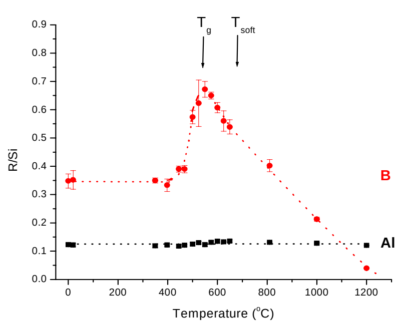
surface composition by FAB SIMS for commercial microsheet glass for FPD

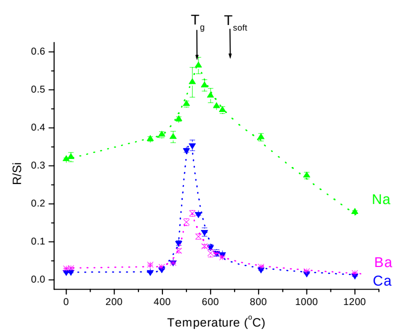




Estimated 'Initial' Molecular Flux of Boron Containing Vapor Species from CGW 1737 Fracture Surface.

Isothermally 'Freezing In' the Surface Composition

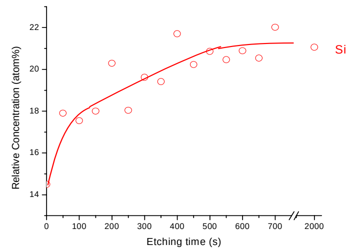


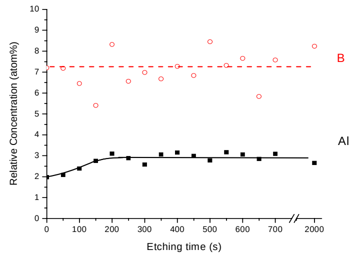


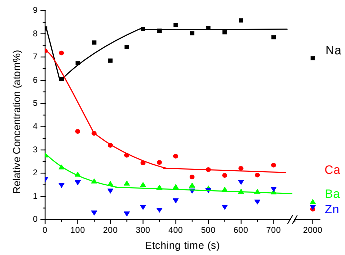
- after heat-treatment at T_g, the surface is depleted in Si. The concentrations of B, Na, Ba and Ca increase significantly on the surface, especially Ca and Ba.
- At temperatures > 800 °C, the surface is depleted in B and Na.
- The Al/Si ratio does not change over the entire temperature range.

Glass VII

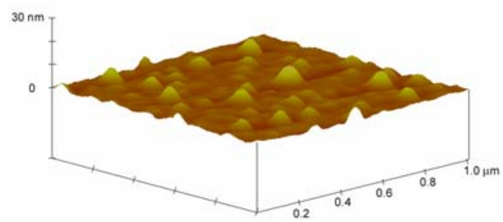
XPS Depth Profiling:
air-fracture surface of glass I,
“equilibrated” at 525 °C.



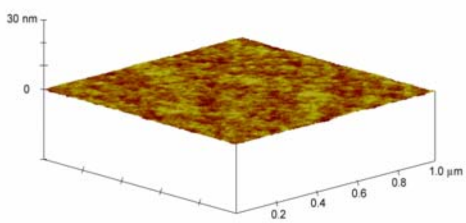




- Sputtering rate ~ 1 Å/s.
- The Si-depleted layer ~200 Å thick.



After: RMS = 0.93 nm



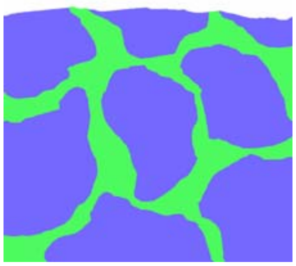
Before: RMS = 0.14 nm

After heat-treatment, features (4-7 nm in height) appear on the surface.

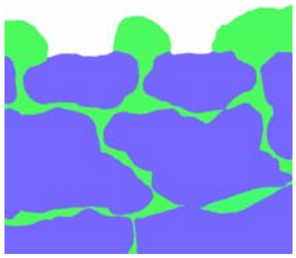
Phenomenological Model

for "Phase Segregation/Migration" to the Surface

Network modifier rich regi[on] Network former rich region



Before Heat-treatment



After Heat-treatment

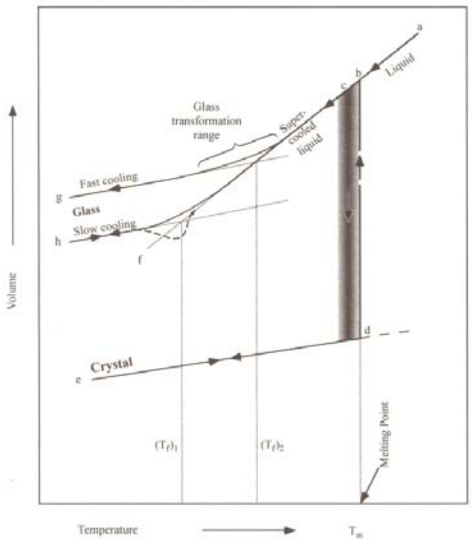
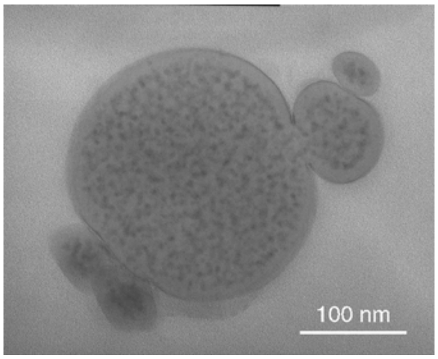
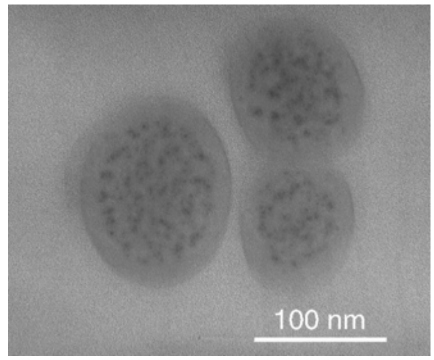


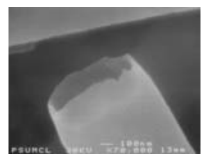
FIGURE 5.1 The volume-temperature diagram. *(After A. K. Varshneya, Fundamentals of Inorganic Glasses, Fig. 2-1, p. 15, Academic Press, 1994.)*

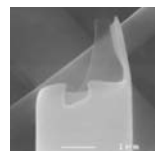
TEM of FA Fibers (Glass A)





after leaching →





Issues and Opportunities at Glass Surfaces

- At high temperature, surface segregation, evaporation, redox, and other surface localized thermochemical phenomena can occur. Upon reaching the Tg, the modified surface composition is frozen in.
- The creation of glass surfaces at high temperatue provides the opportunity to modify the surface of glass fibers or substrates independent of the bulk in some systems; ie, to decouple the bulk glass requirements (processability and optical properties) from the surface requirements (composition and chemical reactivity). **What do you think?**