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

Carlo Pantano
Penn State University

Follow this and additional works at: https://preserve.lehigh.edu/imi-tll-courses-usjapanwinterschool

Part of the Materials Science and Engineering Commons

Recommended Citation

This Video is brought to you for free and open access by the Semester Length Glass Courses and Glass Schools at Lehigh Preserve. It has been accepted for inclusion in US-Japan Winter School by an authorized administrator of Lehigh Preserve. For more information, please contact preserve@lehigh.edu.
Thermochemical Processing Effects at Multicomponent Glass Surfaces

Carlo G Pantano
Department of Materials Science and Engineering
Materials Research Institute
The Pennsylvania State University

Acknowledgements: Bob Hengstebeck
Justin Wood
CQ Shen
Elam Leed
Rob Schaut
Prof Karl Mueller
NSF Center for Glass Research

Continuous Forming of Thin Glass Films: Overview of the State-of-Art

How are flat, thin glass sheets 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glass flows over a weir, downward a blade, through a nozzle, or on a spinning drum to form a film which is continuously withdrawn.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 MICRO SHEET GLASS FABRICATION

![Diagram of a fusion process for microsheet glass fabrication]
Antimony Depth Distribution by Angle-Resolved XPS and FAB-Static SIMS

Heat Treatments were for 10 minutes; samples were then air quenched.
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 $> 800 \, ^\circ C$, 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.

Before: RMS = 0.14 nm

After: RMS = 0.93 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 region](image1)
![Network former rich region](image2)

Before Heat-treatment  After Heat-treatment

**FIGURE 5.1** The volume-temperature diagram. (After A. E. Verwey, *Fundamentals of Ferricities*. Glitter, Fig. 2-4, p. 13. Academic Press, 1964.)
• 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 temperature provides the opportunity to modify the surface of glass fibers or substrates independent of the bulk in some systems; i.e., to decouple the bulk glass requirements (processability and optical properties) from the surface requirements (composition and chemical reactivity). What do you think?