Nobody sees glasses; only glass scientists see glasses

Minoru Tomozawa

Department of Materials Science and Engineering

Rensselaer Polytechnic Institute

Troy, NY 12180-3590 USA

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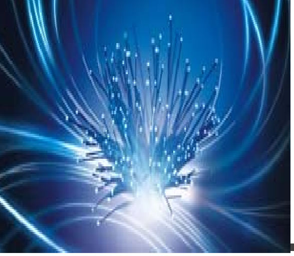


Different glasses

Inorganic glasses – [Organic glasses (polymers)]

Window glasses

Lamps, lenses

TV and computer monitors

(Flat panel display—8 times in 7 years)

Glass bottles

Optical glasses

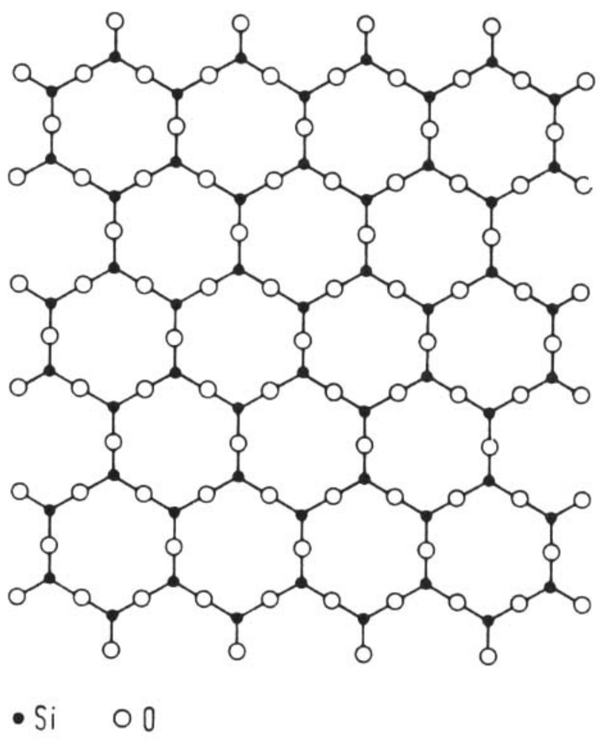
Optical fibers

Fibers for plastic composites and insulation

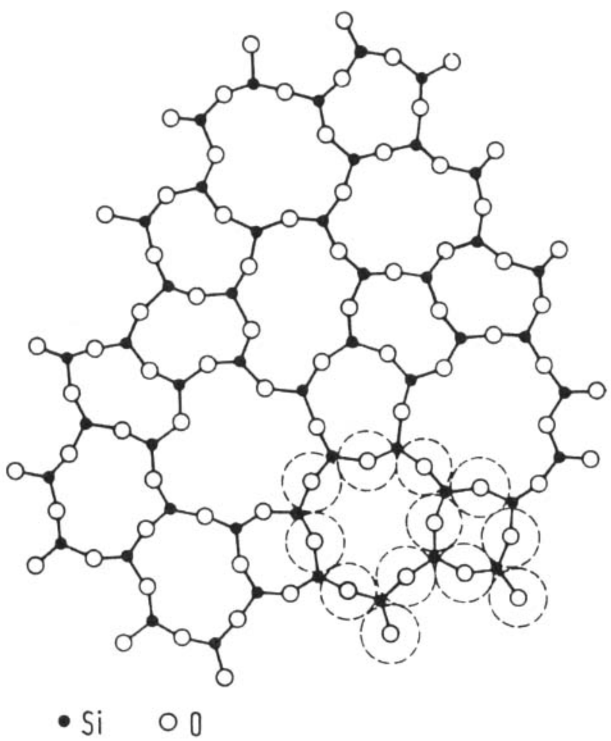
Semiconductors devices (SiO_2)

Natural glasses (geology)

Structure of glasses (SiO_2)

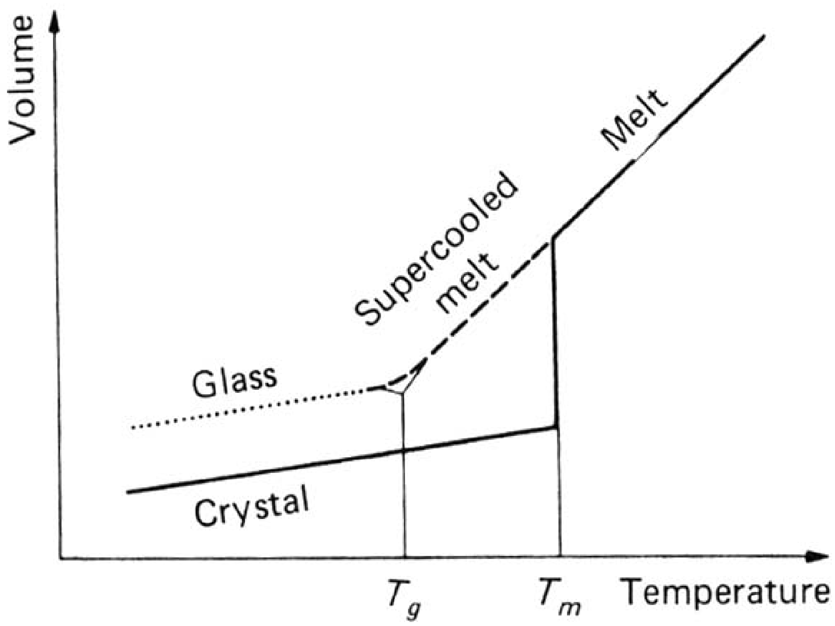


Crystal SiO_2



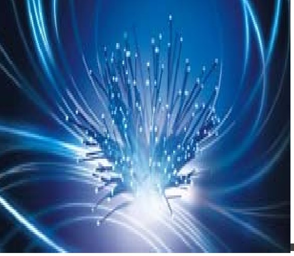
Glass SiO_2

Glass State; Solid? Liquid?



Glass is a liquid which did not crystallize at a lower temperature than its melting point. (metastable state)

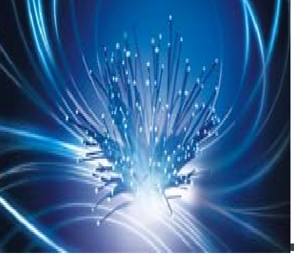
This suggests that any material, including metal, and water can be made into a glass when cooled rapidly.



Viscosity changes with temperature.

Viscosity (difficulty to flow) of glasses change greatly with temperature. At high temperature, glasses become like honey; at low temperature glasses become rigid like rock. At an intermediate temperature, ~ 500°C, the glass can deform slowly and change its dimensions.

This characteristic is a great advantage for mass production of useful products; can cause difficulty in complicate device, e.g. flat panel display, production.



Can glass deform permanently at room temperature?

Antique Windowpanes and the Flow of Supercooled Liquids

Robert C. Plumb
Worcester Polytechnic Institute, Worcester, MA 01609

J. Chem. Education 66, 994 (1989).

Flowing windowpanes: fact or fiction?

BY Y. M. STOKES
Department of Applied Mathematics, The University of Adelaide, South Australia 5005, Australia (ystokes@maths.adelaide.edu.au)

Proc. Roy. Soc., London A455, 2751 (1999).

Ancient glass plate production

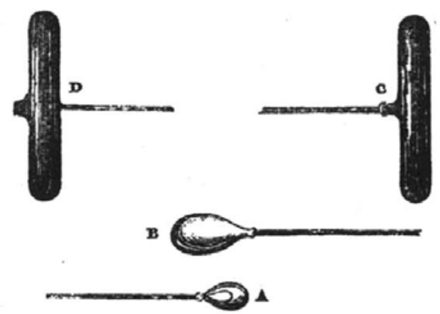


Figure 1. The shapes of the 9 lb of molten glass: A, when gathered; B, blown; C, blown larger and flattened; and D, attached to the "ponty" (known as a punty now) and the blow pipe removed before it was spun to the large disk shape in the flashing furnace. (From ref 7.)

Figure 3. Expanding the open decanter shape to a 60-in.-diameter disk in the flashing furnace. (From ref 7.)

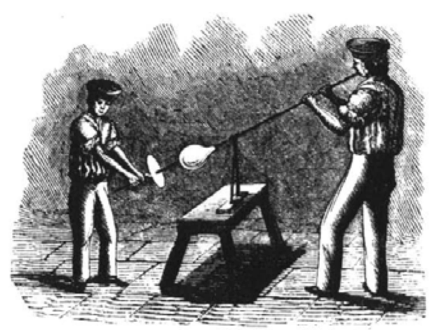


Figure 2. The glass blower enlarging the glass flask, assisted by his helper in keeping the mass of molten glass centered. (From ref 7.)

Ancient glass plate manufacturing process

Can glass deform permanently at room temperature?

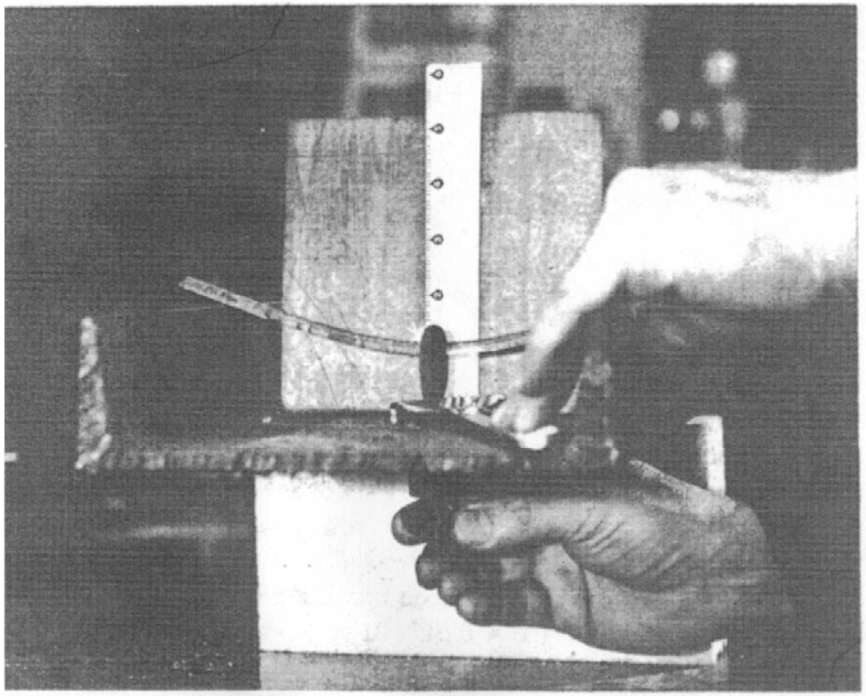


FIG. 6. Etched ½ in. glass rod loaded to 125,000 psi by Phillips in 1936, as it looked in 1962 after 26 years under continuous load.

C.J. Phillips
American Scientist, 53, 20 (1965).

Can glass turn into a stable crystal at room temperature?

Since glass state is in a metastable state, it would try to be more stable by transforming itself into a crystal.

Lybian desert glass; SiO_2 glass
The origin is not clear; million or more years old.

How old is an old glass, stone age glass?

Obsidian Hydration Dating
Science, 191, 347 (1976)
I. Friedman and W. Long

Hydration thickness,
$T = k\,t^{1/2}$

Effects of temperature, obsidian composition were considered.

Hydration dating of glasses

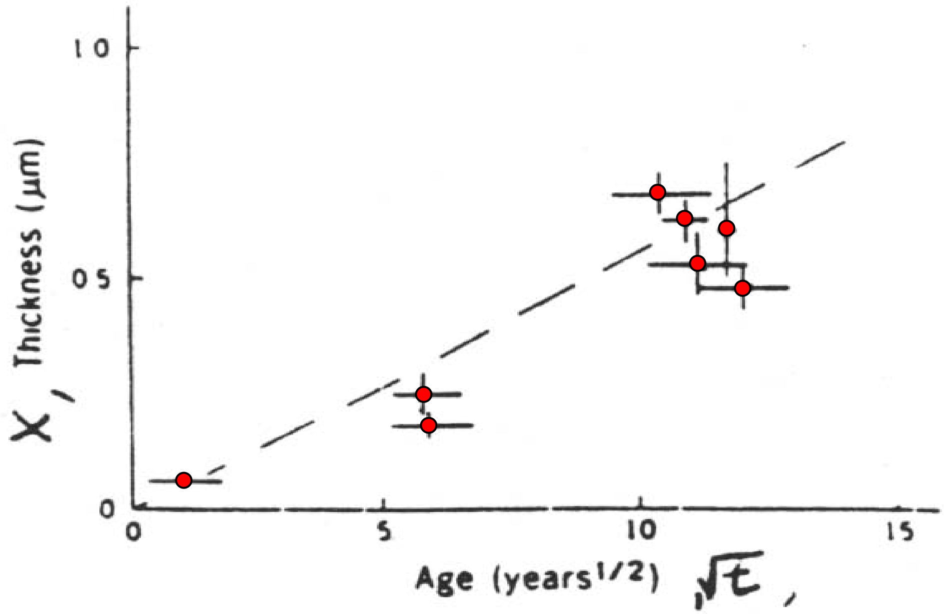


Fig. 1. Summary of the hydration thickness plotted versus the square root of the age of the glass test object, showing a qualitative correlation between age and hydration thickness. The straight line is the correlation expected for $X^2 = Kt$ on the assumption that $K = 3.3$ μm^2 per 1000 years.

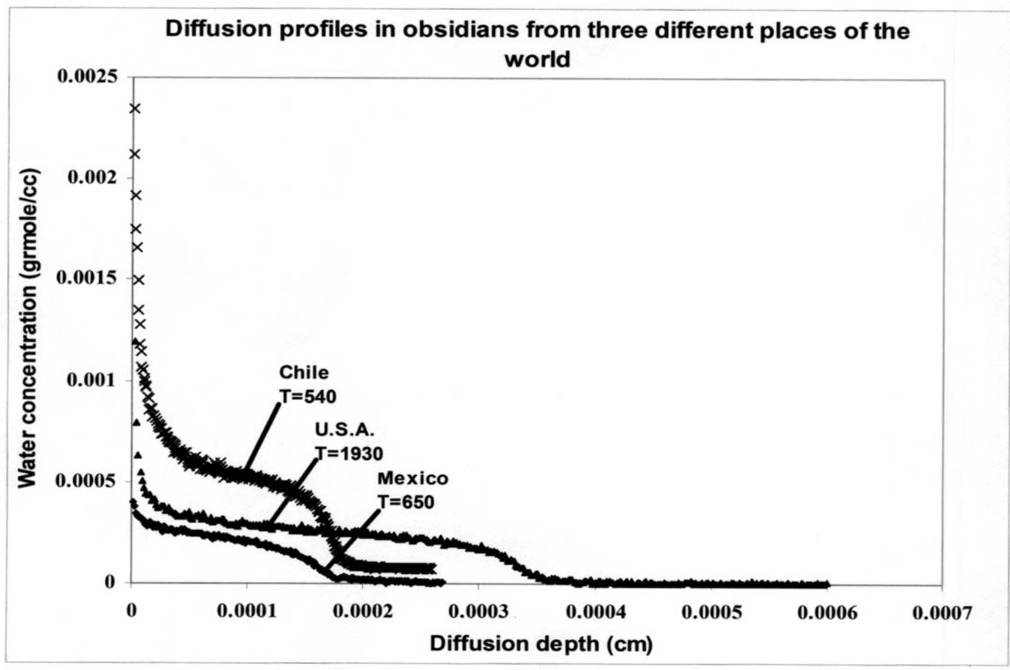
W. A. Lanford
Science, 196
(1977) 975.

Hydration dating of obsidian

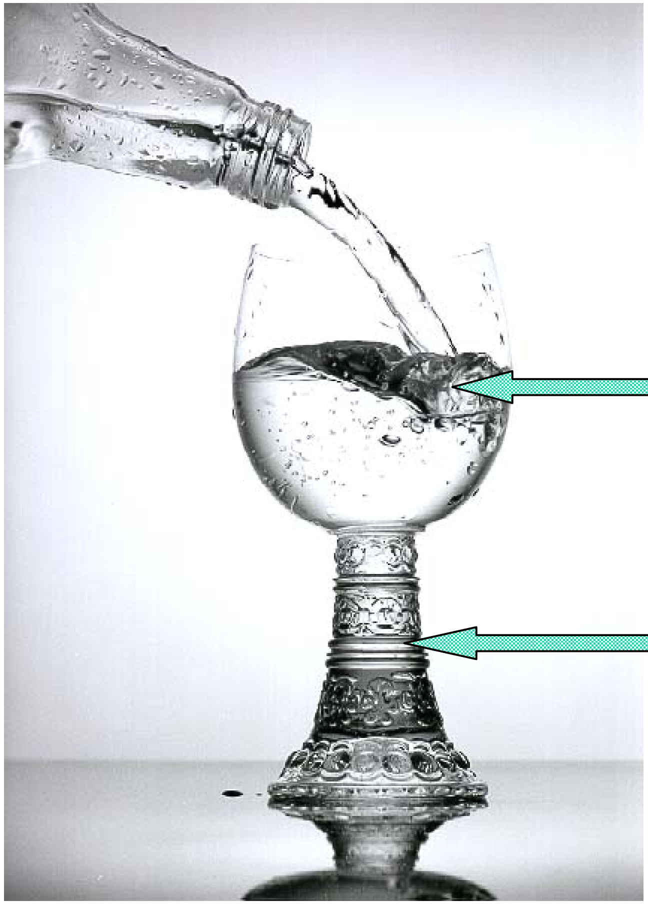
Obsidian Hydration data

By **Ioannis Liritzis and Maria Diakostamatiou**

University of the Aegean, Department of the Mediterranean Studies, Laboratory of Archaeometry , 1 Demokratias Ave., Rhodes 85100, Greece



Water in glass, which is not for drinking



Water in glass

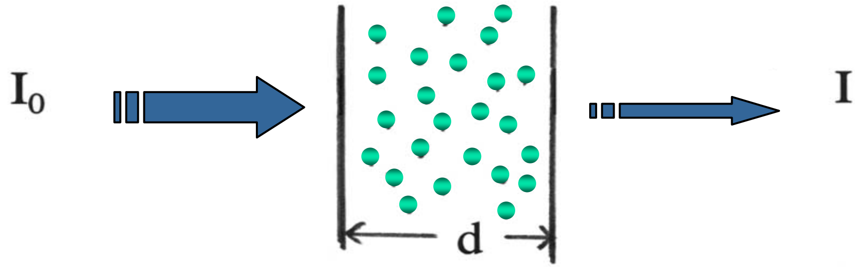
Water in glass

Water in glass absorbs light

(Lambert-)Beer's Law

$$I = I_0\, 10^{-\epsilon c d}$$

I: Transmitted light intensity
I_0: Incident light intensity
ϵ: extinction coefficient
c: concentration
d: thickness



Optical fiber, loss of signal by water

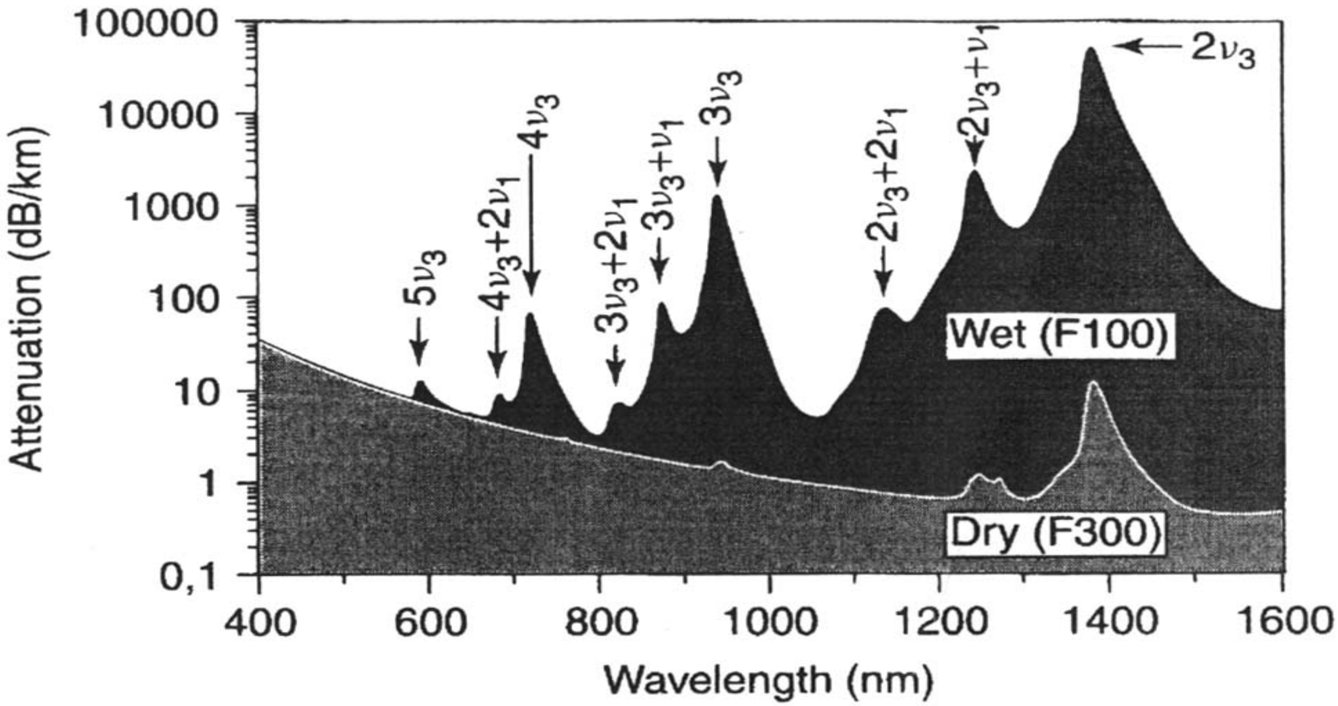


Fig. 36. Attenuation (absorption coefficient) of wet (Heraeus F100) and dry (Heraeus F300) silica glasses [129]. ν_3 and ν_1 represent the OH fundamental mode and the SiO_4 tetrahedron vibration, respectively.

O. Humbach, H. Fabian, U. Grezesik, U. Haken and W. Heitmann, J. Non-Cryst. Solids, 203 (1996) 19.

Glass can get tired in moisture

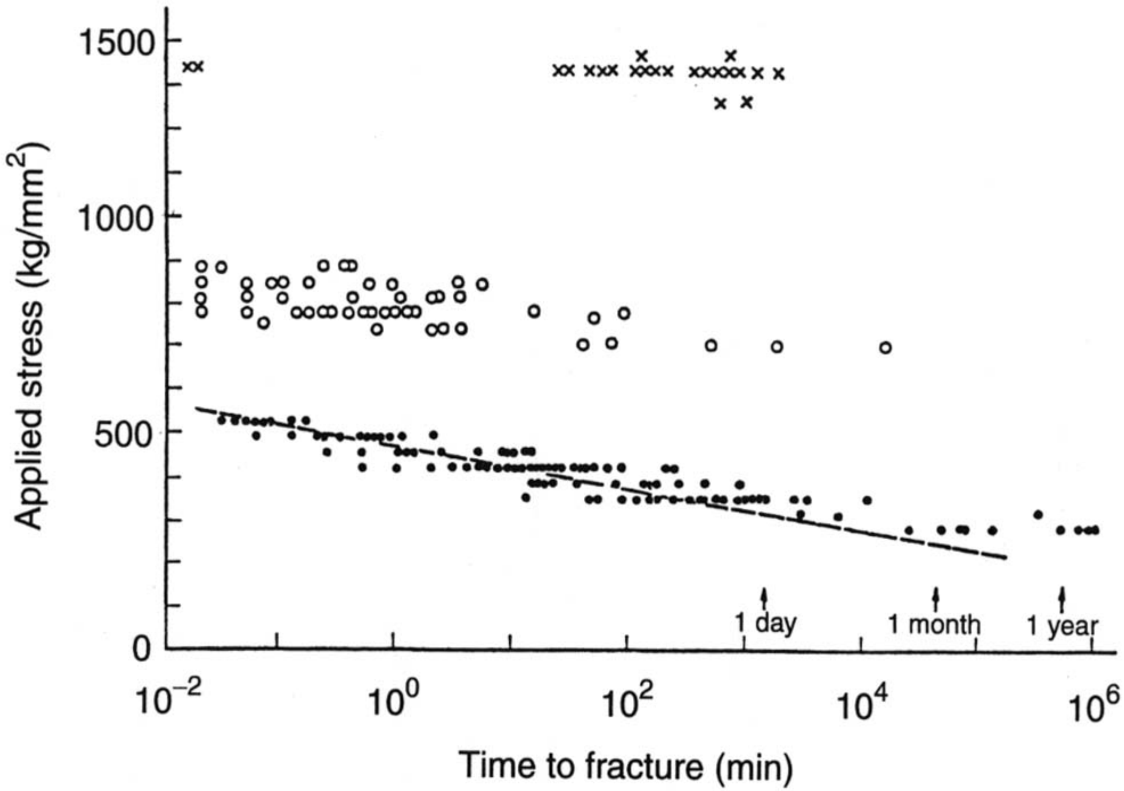
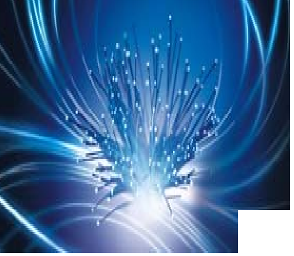


Fig. 31. Static fatigue of silica glass fibers at room temperature in air and in vacuo, and at liquid nitrogen temperature in vacuo: (•) in air at room temperature; (○) in vacuo at room temperature; (x) in vacuo at −196 °C; (- - - -). a straight line approximation [115].

B.A.Proctor, I. Whitney and J.W. Hohnson, Proc. Roy. Soc. A297 (1967) 534



Optical fibers get tired faster?

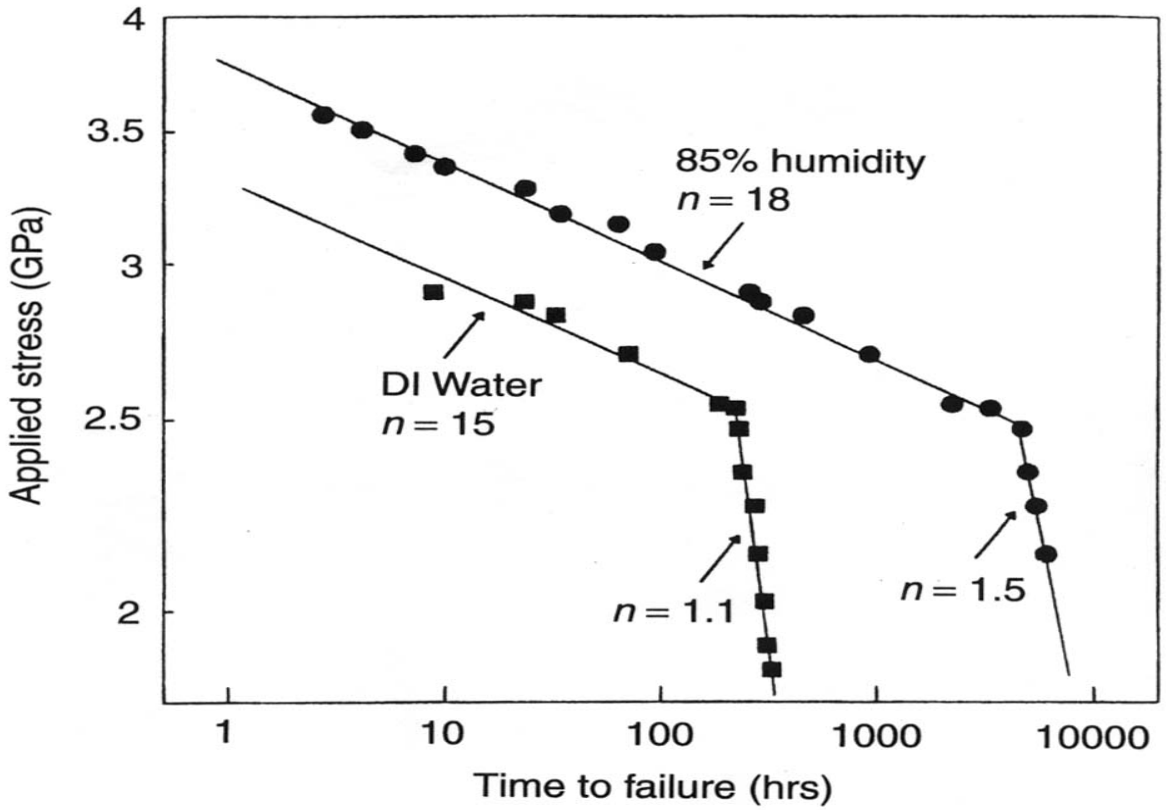


Fig. 32. Static fatigue of silica communication fiber in DI water and in air with 85% humidity at 85 °C [117]. The parameter n represents fatigue resistance as in log(applied stress) = constant − $(1/n)$ log(time of failure). Larger n values indicate greater fatigue resistance.

M.J. Matthewson, and H.H. Yuce, SPIE, vol.2290 (1994) 204.

How strong was a broken glass?

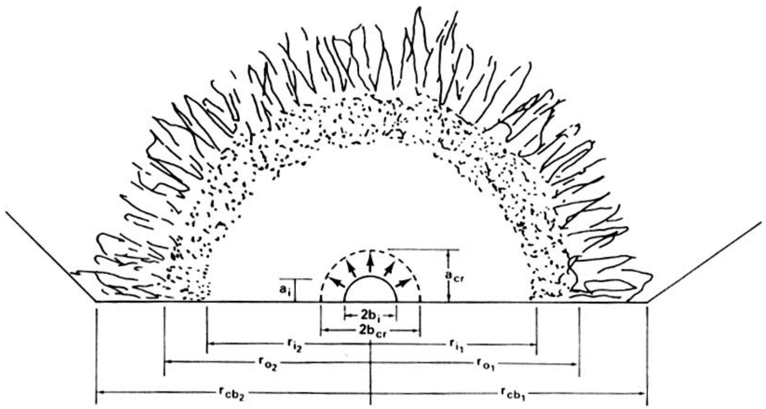


FIG. 8. Schematic of features observed on a glass fracture surface: r_i, mist boundary; r_o, hackle boundary; r_{ob}, macroscopic crack branching; a_i, initial flaw size; a_{cr}, size at which flaw extends catastrophically (no markings are left on the surface at this point). $(a_{cr}b_{cr})^{1/2}/r$ = const; $\rho r^{1/2}$ = const.

S.W. Freiman, p.31 in Glass Science and Technology, vol. 5, Ed. By D.R. Uhlmann and N.J. Kreidl

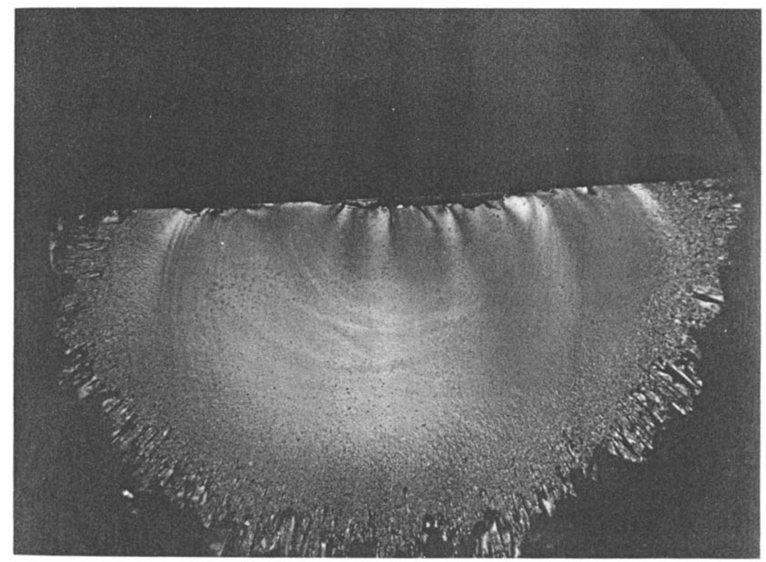


FIG. 9. Typical mist and hackle formed on glass; flaw is elongated crack at the tensile surface.

Freiman (1980)

Strength of broken glass can be estimated

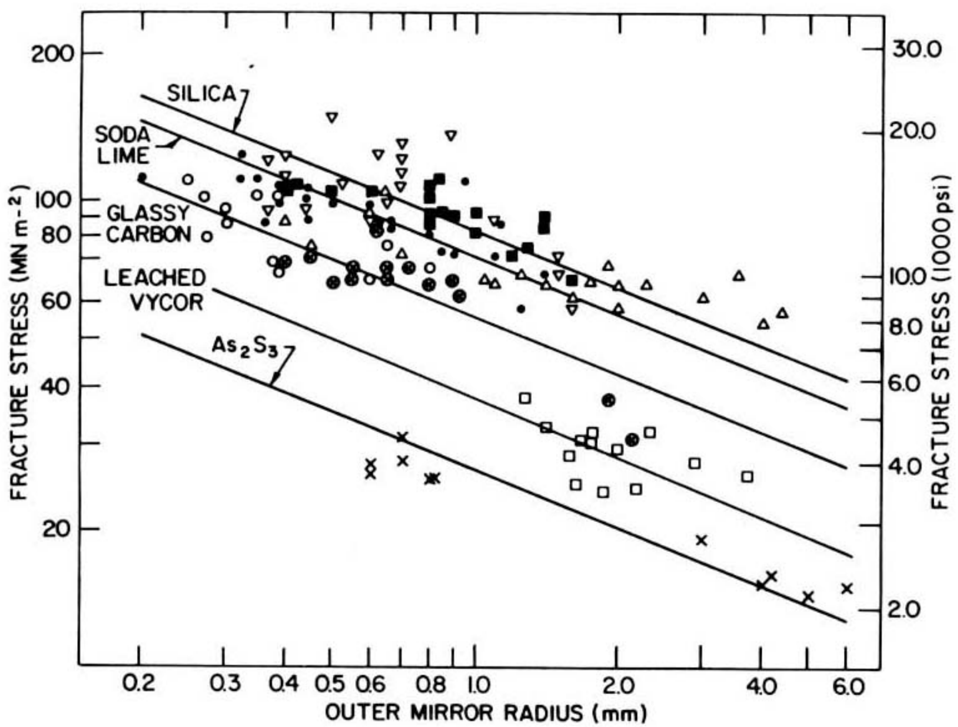


FIG. 10. Strength-mirror size data for various glasses x, As_2S_3; ○, glassy carbon; ■, borosilicate; ●, soda lime; Δ, SiO_2 glass; ∇, aluminosilicate; ●, lead silicate; □, leached Vycor. (Mecholsky *et al.*, 1974.)

Mirror Constant

$$\sigma_f = A/\sqrt{r}$$

σ_f : fracture strength
r: mirror radius
A: mirror constant

$$\log \sigma_f = \log A - (1/2) \log r$$

Mecholsky et al., 1974

J.J. Mecholsky, R.W. Rice and S.W. Freiman, J. Am. Ceram. Soc., 57 (1974) 440.

Best nuclear waste processing method?

Currently, nuclear waste is stored in liquid form in stainless steel containers—can leak

Vitrification—Billion dollar facilities
Savannah River, GA, Richland, WA

Bury the glasses in safe site (depository)
Yaca Mountain site
For thousands of years.

Space shuttle tiles are glass fibers

SiO_2 glass fibers bonded together.

- Has to withstand high temperature of 1300^{o}C to protect astronauts

- Light weight

Can a glass be made stronger?

A person living in a glass house should not throw a stone.

Glass jaw.

- Tempering
- Ion-exchange

Recent Severe Hailstorm in New Mexico

S. Jill Glass
Sandia National Labs.


HONDA
CIVIC


CHEVROLET

Glass testing at Sandia National Laboratories

This video available for viewing on the IMI website at
http://www.lehigh.edu/~inimif/resources.htm

Contact: S. Jill Glass,
Sandia National Laboratories

Thermal tempering

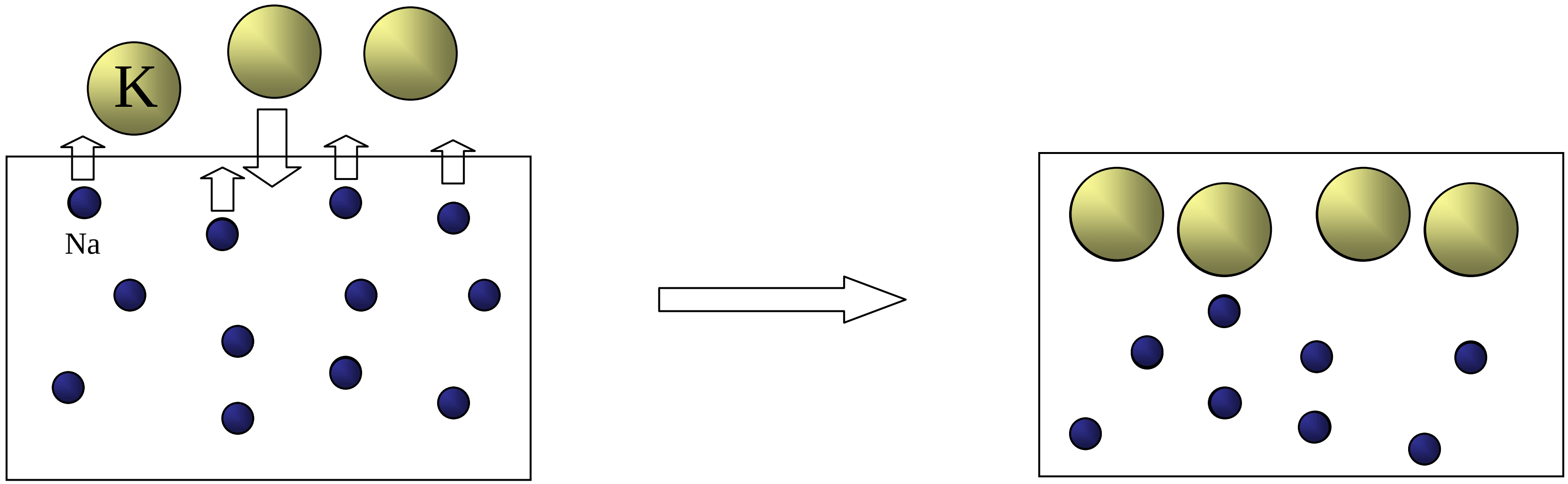
- Glasses are heated to high temperature and then quickly cooled by jet of air.

- Glass can be made stronger by several times.
- Glasses shatter into pieces when broken.

Ion-exchange

Smaller Na^+ ions in glass are exchanged with larger K^+ ions from outside (molten salt).

Glass becomes stronger by 30 times or more.



Exchange of a Na-containing glass in a bath of molten KNO_3 salt

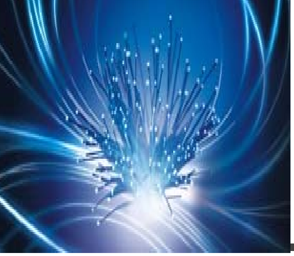
Use of high strength glasses?

Glass can be made stronger.

With improved strength, glass products can be made thinner and lighter weight.

For example, containers--Competition of glass, plastic and metal. Glasses were the main container materials. Then metals and plastics became popular.

With high price of oils, and electricity, glass containers may become popular again.



Conclusions

- Glasses are used in a variety of different technological fields. Also, it poses interesting (philosophical questions)
- The glass state is considered one of the remaining frontier of science.

Acknowledgement

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