Forensic Analysis of Glass: Part2

Forensic Science

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Quantitative Properties of Glass

Table 2.3 Physical Properties of Glass

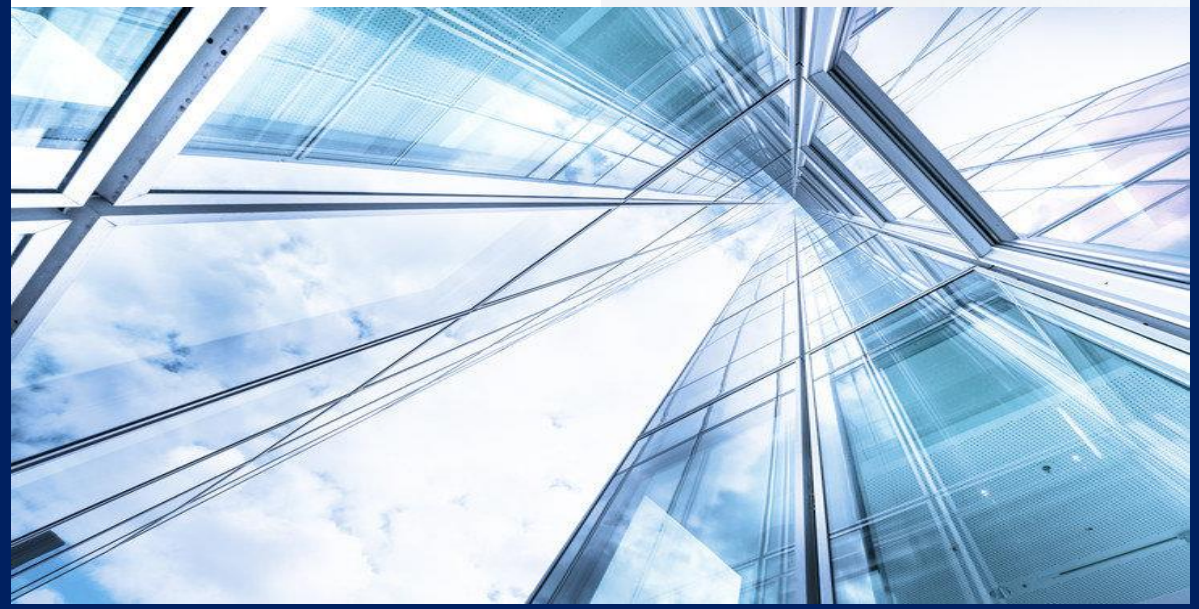
Type	Softening Point[1] (°C)	Density (g/mL)	Refractive Index[2]
Alkali barium	646	2.64	1.511
Alkali barium (optical)	647	2.60	1.512
Alkali barium borosilicate	712	2.27	1.484
Alkali borosilicate	718	2.29	1.486
Alkali strontium	688	2.26	1.519
Alkali zinc borosilicate	720	2.57	1.523
Borosilicate	720	2.28	1.490
Baria alumina borosilicate	844	2.76	1.530
Barium-alumina borosilicate	847	2.96	1.545
Borosilicate	821	2.23	1.473
Lanthanum barium	759	3.98	1.678
Lead borosilicate	447	5.46	1.860
Lead zinc borosilicate	370	3.80	—
Lithia potash borosilicate	—	2.13	1.469
Potash borosilicate	820	2.16	1.465
Potash soda lead	630	3.05	1.560
96% Silica	1530	2.18	1.458
96% Silica (porous)	1530	1.50	—
Silica (99.9% fused)	1585	2.20	1.459
Soda borosilicate	808	2.27	1.476
Soda alumina borosilicate	705	2.17	1.468
Soda-lime	696	2.47	1.510

[1]The softening point is the temperature at which heated glass starts to deform under its own weight.
[2]The refractive index of all samples is measured at a wavelength of 589.3 nm.

Table 2-3
Investigating Chemistry, First Edition

Why Measure Density?

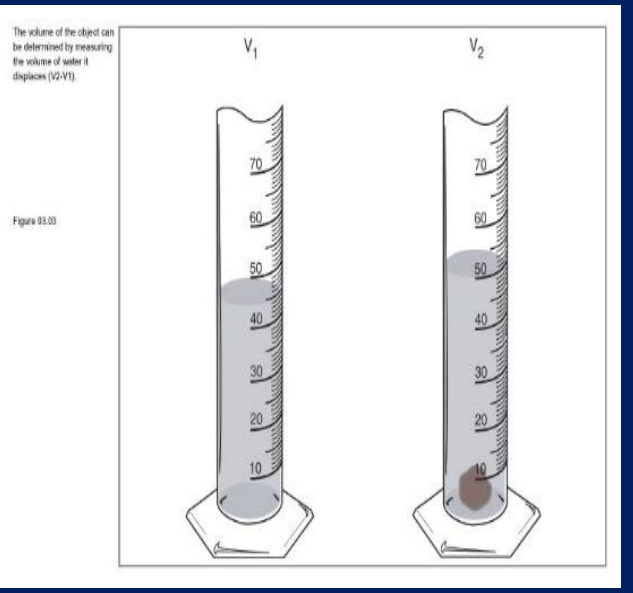
- Can be used as a screening technique with large numbers of fragments.
- Useful in identifying multiple sources present in the known and/or questioned samples.
- It is nondestructive and an intensive property (not dependent on sample mass).
- Need to measure very precisely in parts per hundred or thousand or better.



Glass Density

- Density can be measured by:
  - directly determining mass and volume (usually by displacement)
  - comparison by flotation
  - comparison using a density gradient column

- Density gradient column method:
  - Fragments of different densities settle at different levels in the column of liquid of varying density.
  - Technique is not accurate for fragments that are cracked or contain an inclusion.



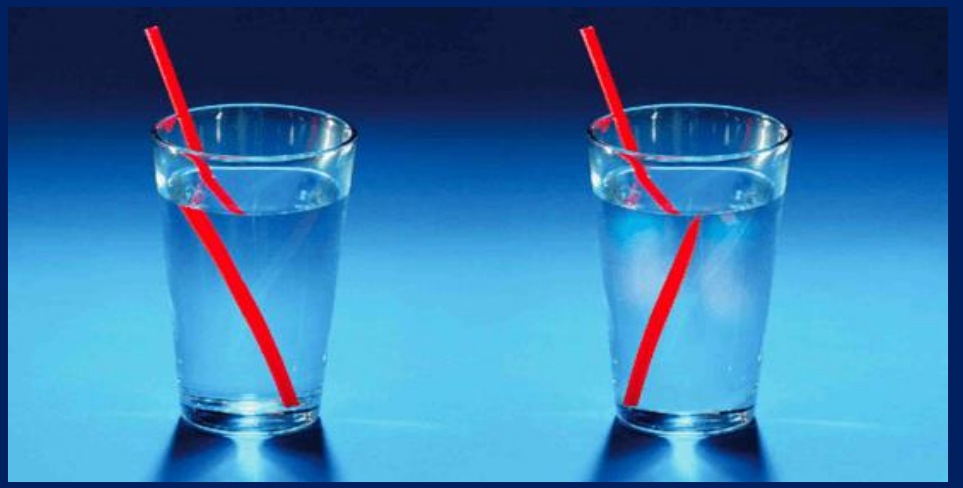
Density by the Flotation Method

- **A glass particle is immersed in a liquid. The density of the liquid is adjusted by the addition of small amounts of another liquid until the glass chip remains suspended.**

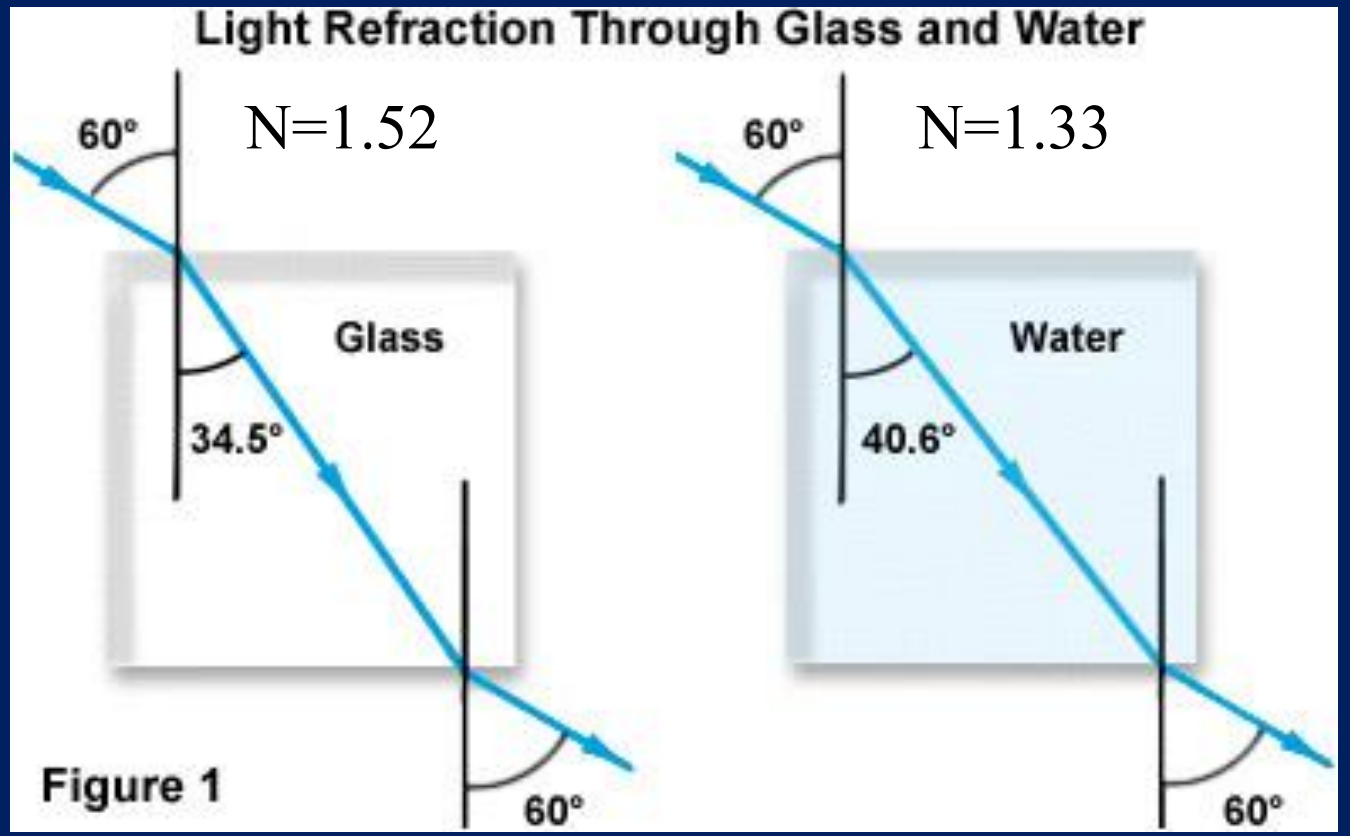
- **At this point, the glass will have the same density as the liquid medium and can be compared to other relevant pieces of glass which will remain suspended, sink, or float.**

Why Measure Refractive Index?

- **Refractive index: ratio of the velocity of light in a vacuum to the velocity of light in any other medium**
- **For example, at 25ºC the refractive index of water is 1.333. This means that light travels 1.333 times faster in a vacuum than it does in water.**
- **Like density, refractive index is an intensive property but it can be measured very precisely (±0.0002) and does not destroy the sample.**
- **Refractive index of glass varies with small changes in composition or by how it is manufactured.**



Snell's Law



The higher the *n*, the more the light bends

Refractive Index By Immersion

A hot stage microscope is a key instrument in the forensic examination of glass.

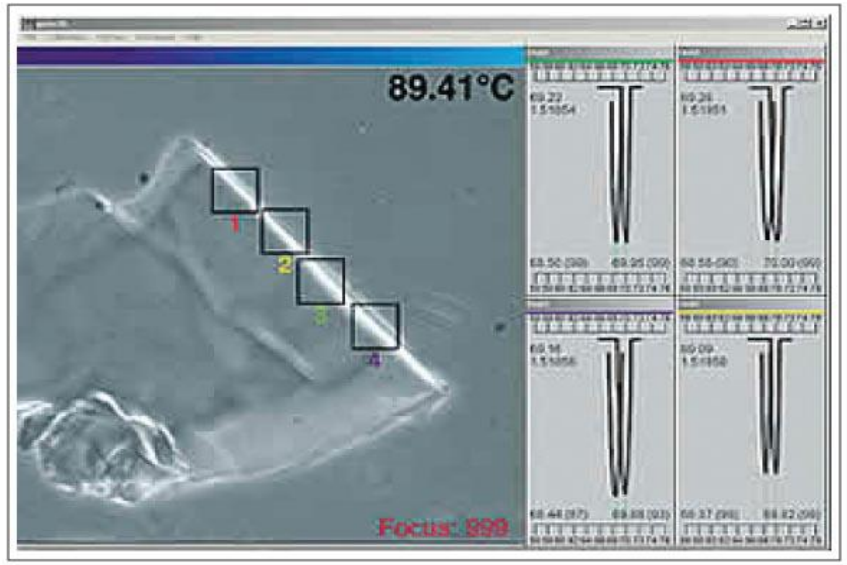
Figure 05.07

Courtesy of Foster & Freeman Ltd.

The GRIM 3 system is an automated technology for the measurement of the refractive index of glass.

Figure 05.09

Courtesy of Foster & Freeman Ltd.



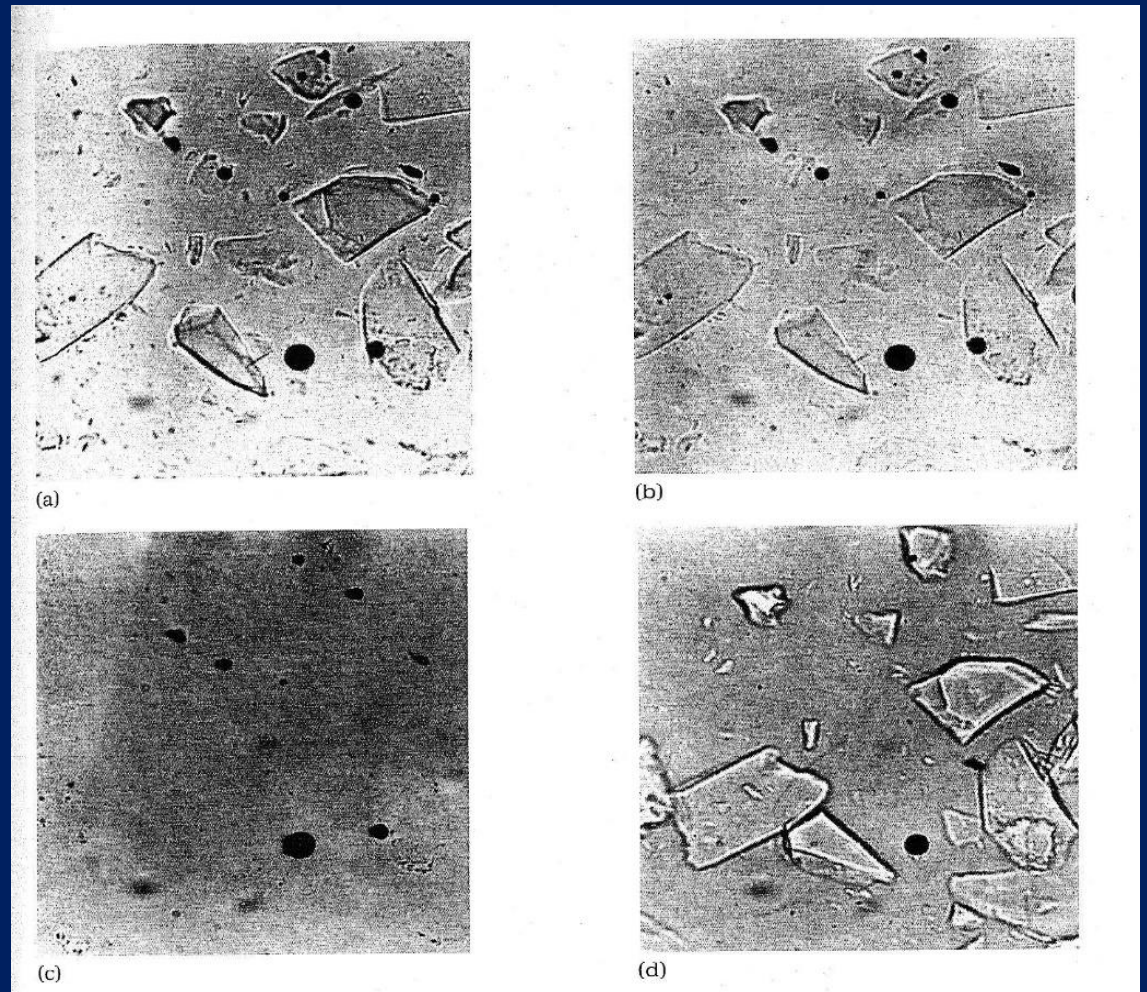
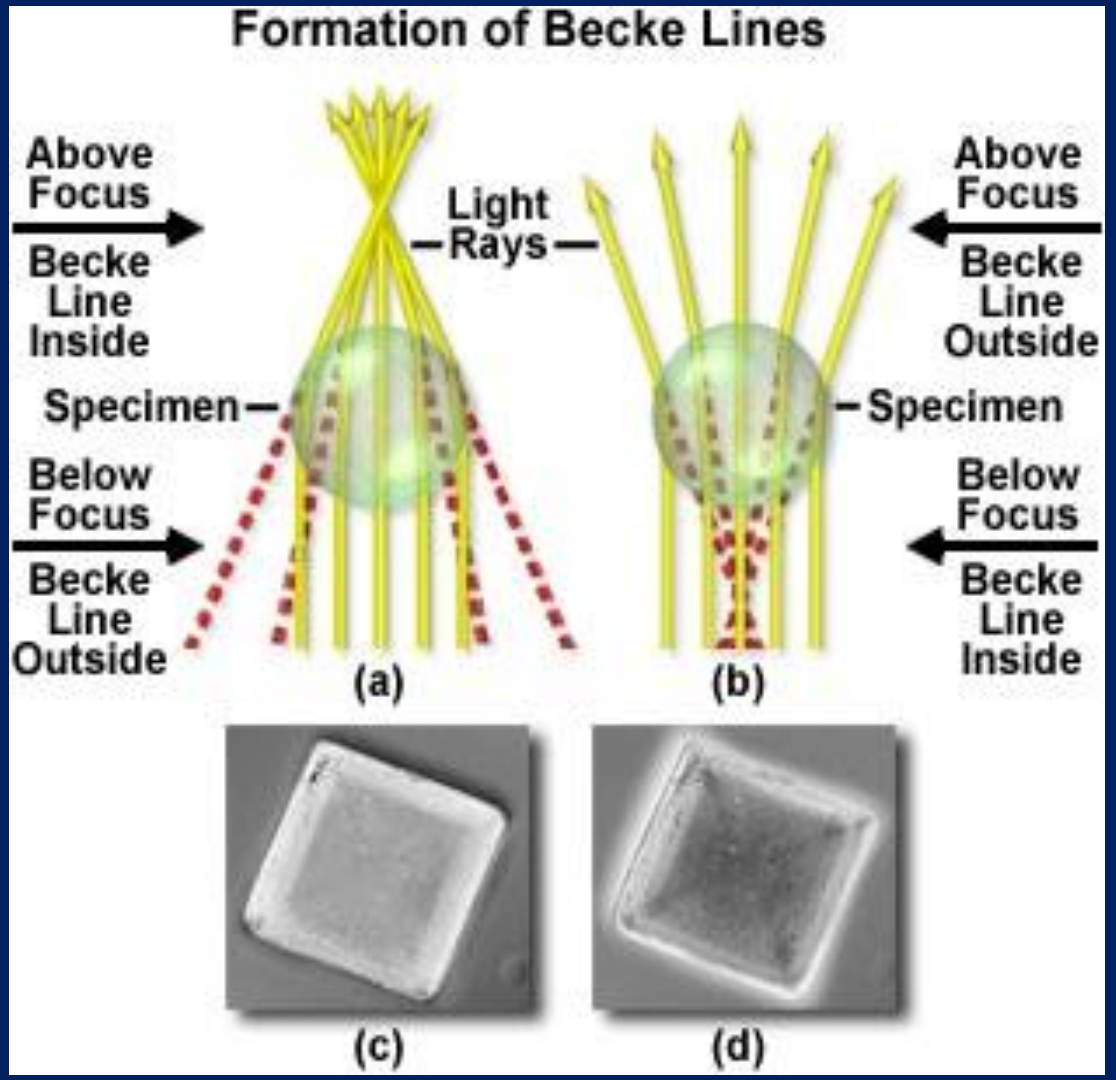


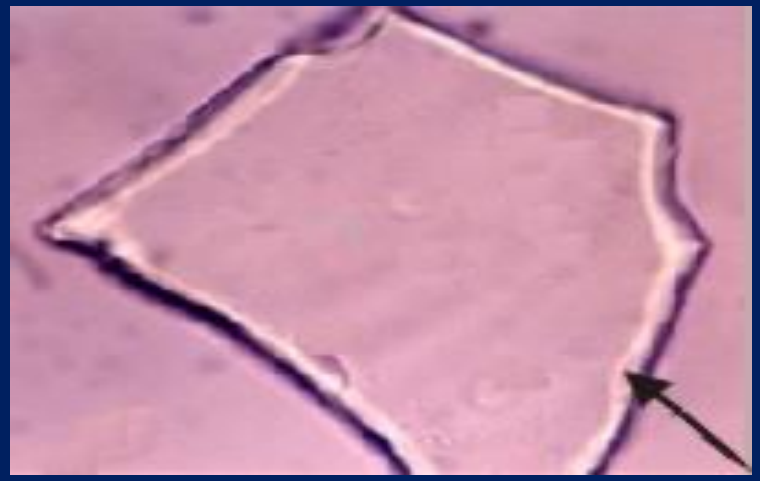
Figure 4–12 Determination of the refractive index of glass. (a) Glass particles are immersed in a liquid of a much higher refractive index at a temperature of 77°C. (b) At 87°C the liquid still has a higher refractive index than the glass. (c) The refractive index of the liquid is closest to that of the glass at 97°C, as shown by the disappearance of the glass and the Becke lines. (d) At the higher temperature of 117°C, the liquid has a much lower index than the glass, and the glass is plainly visible. *Courtesy Walter C. McCrone*

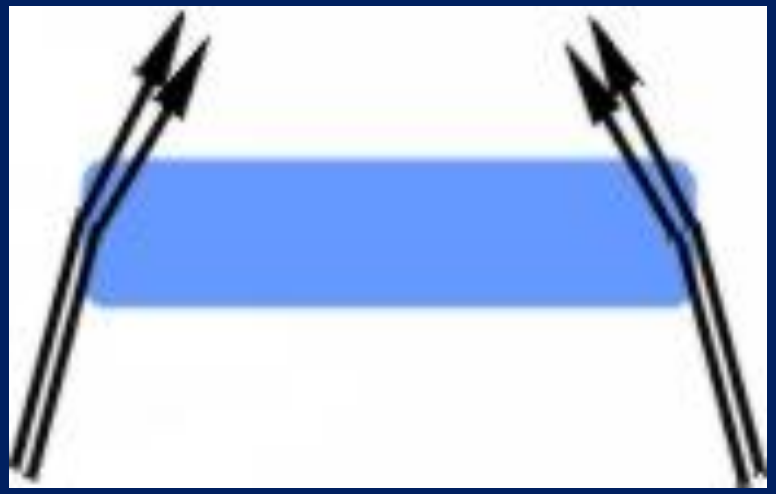
Refractive Index By Immersion

- **Immersing a glass particle in a liquid medium (silicone oil) whose refractive index can varied with temperature until it is equal to that of the glass particle.**
- **At this point, known as the match point, the Becke line disappears and minimum contrast between liquid and particle is observed: RI oil = RI glass.**
- **The Becke line is a bright halo near the boarder of a particle that is immersed in a liquid of a different refractive index.**

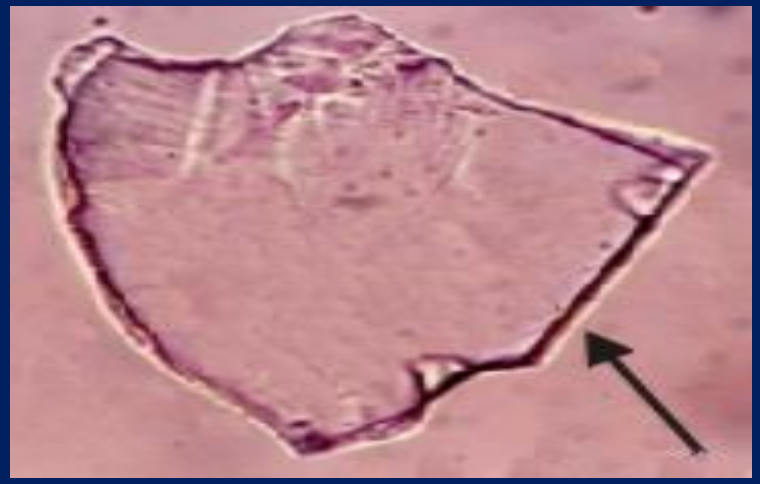


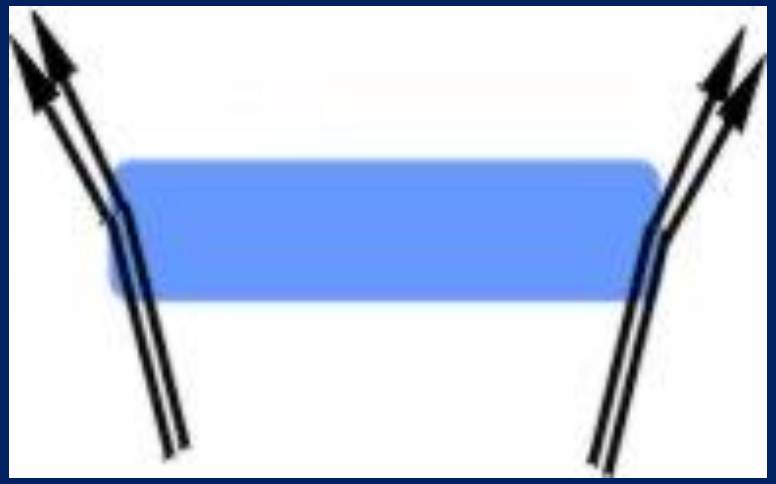
Becke Lines





Glass has higher refractive index-note white line inside



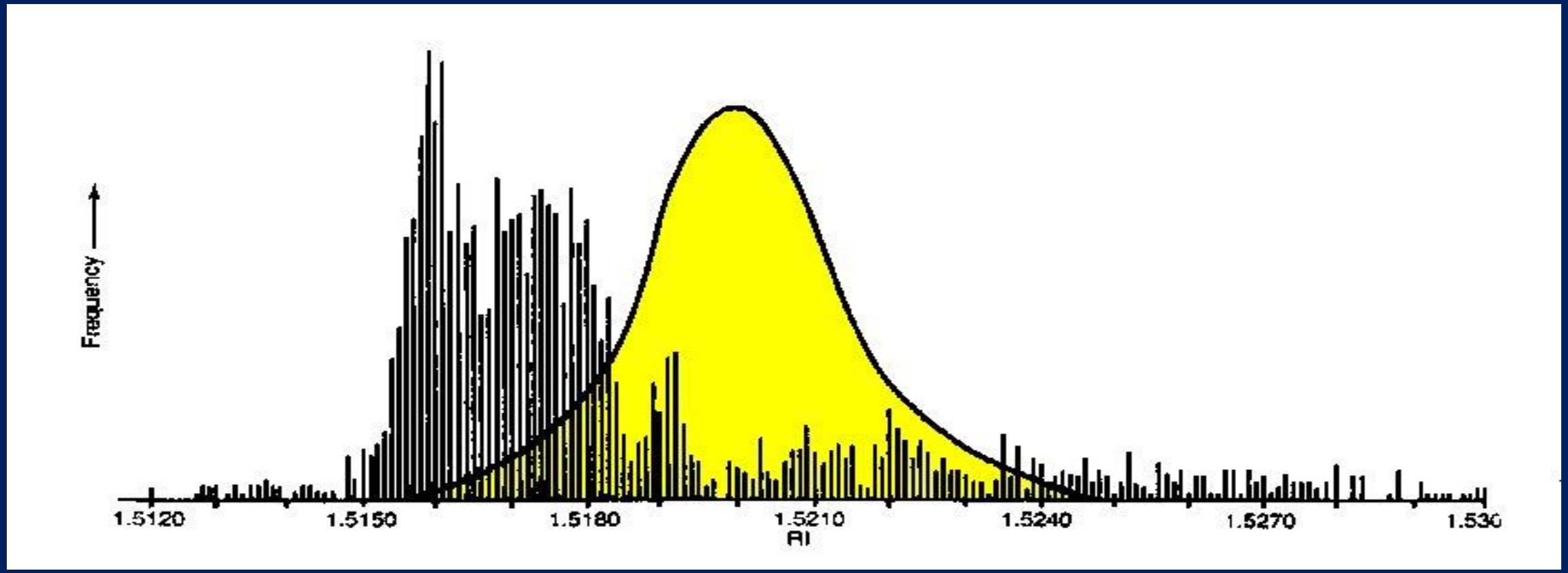


Glass has lower refractive index-note white line outside

Problems with Refractive Index

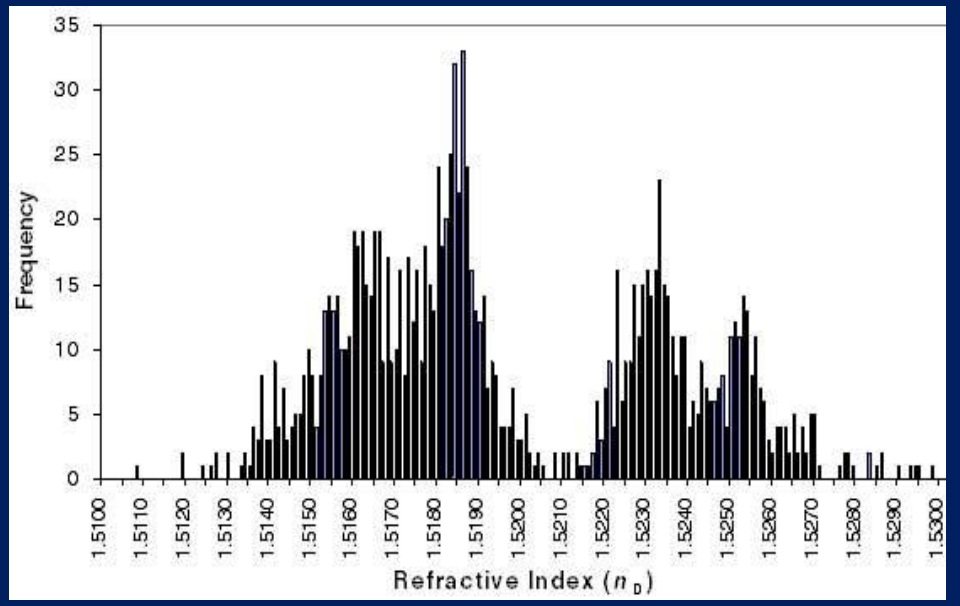
The measurement of RI alone can be of limited use because RI distributions of flat glasses and container glasses overlap.

Histogram = flat glasses
Curve = container glasses

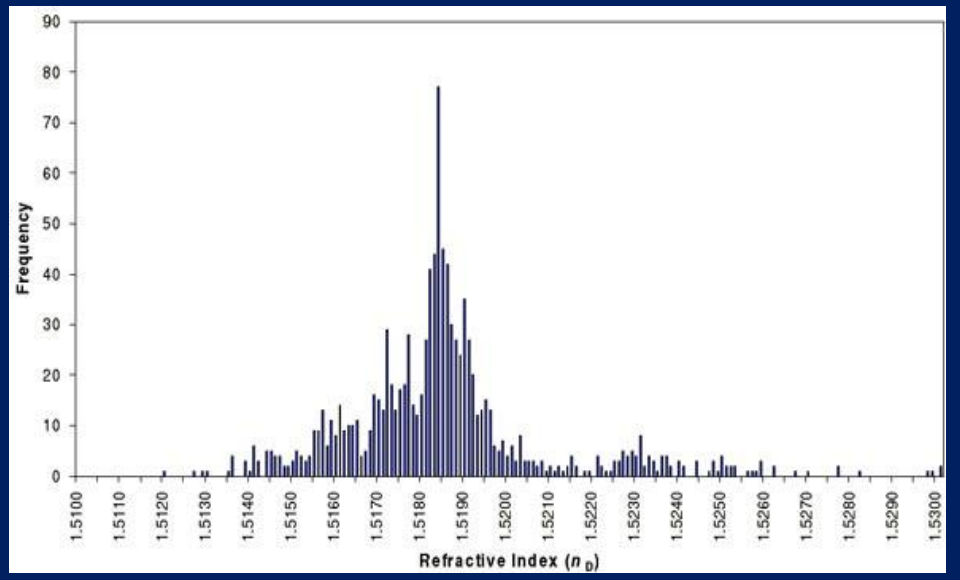


Problems with Refractive Index

A rough statistical estimate of the likelihood of finding glass of that refractive before 1970



Manufacturing changed in late 1970's making glass more uniform



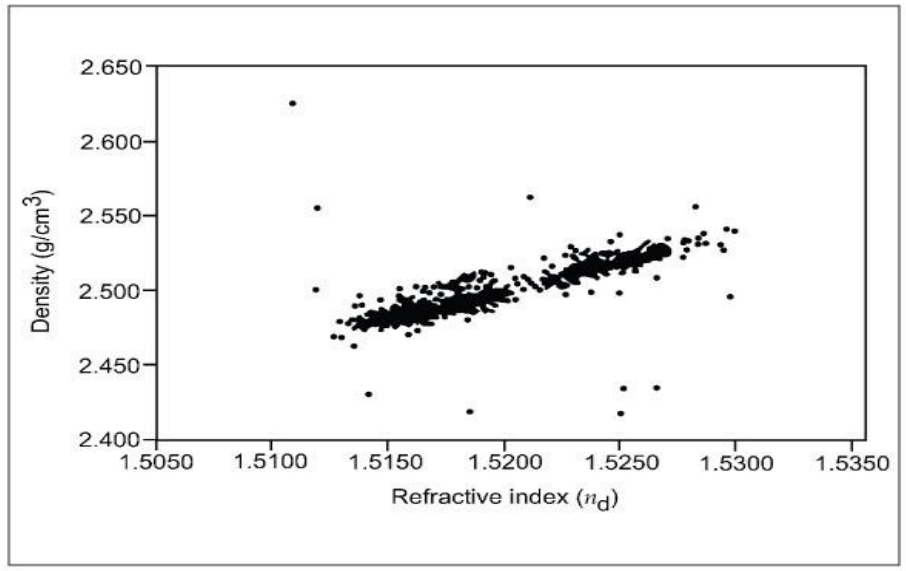
FBI Refractive Index vs Density Data

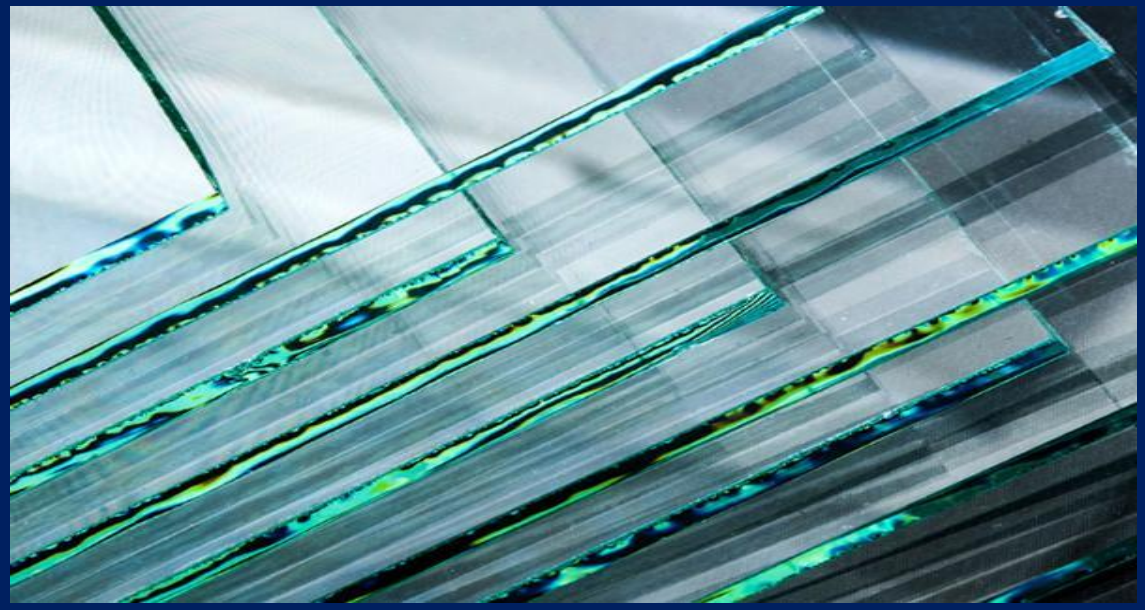
- The FBI has compiled density and refractive index data for glass from around the world.

- The FBI has identified a relationship between their refractive indices and densities for 1400 glass specimens that is better at classification.

The FBI has corrrelated the densities and refractive indices for a wide variety of glass specimens.

Figure 05.11

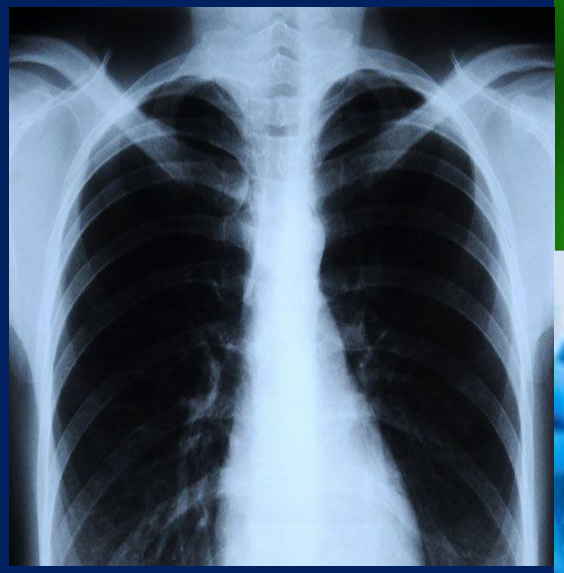




Chemical Analysis of Glass

- **Fluorescence**
  - **Under UV radiation, many glasses exhibit fluorescence (glow)**
  - **Caused by heavy metals (including tin) from "float" process or organic coatings**

- **Scanning Electron Microscopy Energy Dispersive X-ray Analysis**
  - **Can determine many elements simultaneously**
  - **Surfaces of samples (>50 mg) can be analyzed**

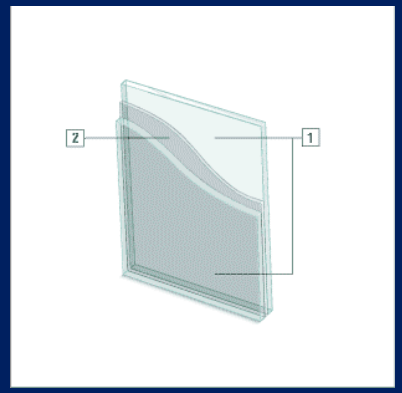


- **Atomic Absorption Spectroscopy**
  - **You must first know which elements are present**
  - **Can analyze ppm levels of elements present**

Learning Check

1. **Which unique chemical component would be found in each type of glass shown below?**

(beaker) **(windshield)** **(crystal)**



2. Use “Table 2.3” to determine if lead borosilicate glass can be distinguished from borosilicate glass by density, refractive index, or both.

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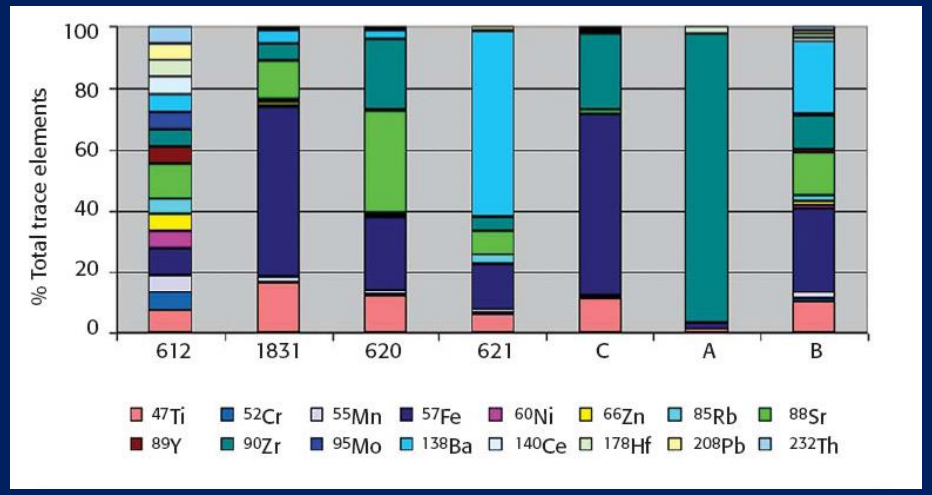
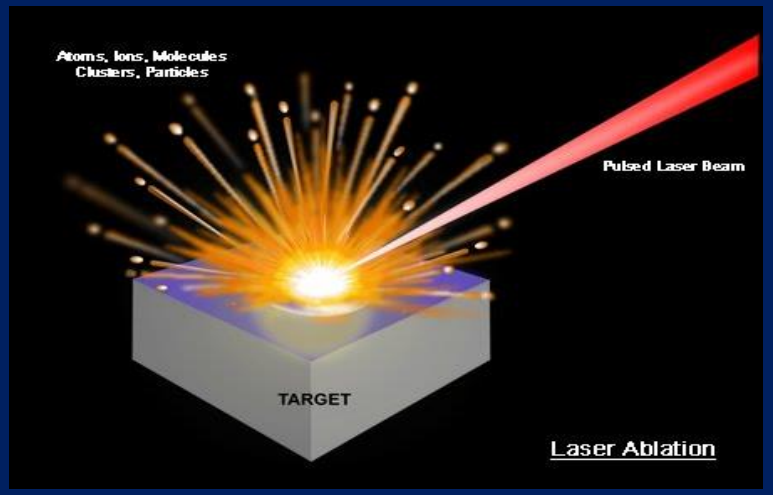
The Wave of the Future: Laser Ablation

- **Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS)**
  - **Laser burns off a microscopic sample**
  - **Elements are ionized by plasma**
  - **Detects 46 trace elements and their isotopes simultaneously in glass at < 1 ppb**





THANK YOU!! .
Questions and Comments