



# History of Glass | *From ancient blades and scalpels, to drink containers and to works of art for the ancient rich, to common household use!*

## What is Glass

Glass is generally based on Silicon Dioxide/Silica ( $\text{SiO}_2$ ) from quartz based pure sand, with different fluxing agents or additives that change the nature of the product. Glass is a quenched liquid formed into an amorphous solid that has minimal crystalline structure as shown for the most used soda glass in figure 1(a).

Modern soda-lime glass is the most common form of glass produced. It is composed of  $\sim 70\%$  silica ( $\text{SiO}_2$ ), 15% soda (sodium oxide from sodium carbonate), and 9% lime (calcium oxide from calcium carbonate), with much smaller amounts of various other compounds. Softening temperature is generally  $\sim 700^\circ\text{C}$ , working temperature of  $\sim 150^\circ\text{C}$ , and able to withstand  $\sim 50\text{-}60^\circ\text{C}$  differential thermal shock before shattering.



**Figure 1:** (a) typical glass amorphous solid liquid structure compared to quartz crystal; (b) Obsidian glass used for arrow heads; (c) A fulgurite (“frozen lightning”) Quartz glass found on a beach; (d) Ancient Greek Glass Amphora circa 150 BC (left) and 4<sup>th</sup> Century Roman Glass Cage Cup AD(right)

## First glass use and production:

**Discussion 1:** The oldest form of glass used by Neolithic humans is natural volcanic obsidian or 70% silica glass, with varying constituents mainly of Magnesium Oxide and Magnetite (Black Iron Oxide  $\text{Fe}_3\text{O}_4$ ). This volcanic glass is similar to granite in composition, but has chilled too quick for quartz crystals to form. Obsidian can produce cutting edges many times finer than even the best steel scalpels. At 30 angstroms – an angstrom is equal to one hundred millionth of a centimetre – an obsidian scalpel can rival diamond in the fineness of its edge; and has been used as weapons, scrapers, and for knives for craniectomy brain surgery since pre-historic times. Silica glass is also formed by severe lightning strikes on sandy beaches or mountain ridges with sand patches, and produces what is known as fulgurites (petrified lightning), see fig. 1(c).

**Discussion 2:** Glass manufacturing is thought to have started 4000 years ago, due to the natron trade. Natron is the hydrated sodium carbonate with the formula  $\text{Na}_2(\text{CO}_3)10(\text{H}_2\text{O})$  rock mineral used and much sought after originally for mummification in Egypt. It is possible that Phoenician (Syrian) merchants who traded this natural desert saltpan rock,

used them to make fires on beach sides, and the combination of the sodium salt and quartz in the sand produced beads of glass. This gradually changed after decades of observation into the first glass making using plant potash as a flux and finely crushed quartz sand, heated to  $750^\circ\text{C}$ . By 1500 BC glass making in Palestine and Egypt occurred for glass vessels. It was not until 1st century BC that Syrians invented glass blowing. Later the Romans spread this technique to Galicia (part of Portugal), Germany and France.

## Why does glass appear translucent?

**Discussion 3:** Visible light photons (packages of electro-magnetic energy) do not have sufficient energy to excite the closely bound electrons in oxide glasses (e.g.  $\text{SiO}_4$ ). Therefore they just pass through the glass matrix as being transparent. However ultra-violet some UVA light, and all UVB/C is absorbed by the glass, and is opaque and heats the glass. **Question: Can you get a suntan/sunburn or make vitamin D with light that has come through the common window pane?** At the other end of the spectrum, near-infra-red created at near room temperature matter is blocked, however longer wave infra-red (e.g. radiant and wood combustion stove heaters) is transmitted through glass losing room heat rapidly. Normal window glass has only a 4% reflected loss of visible light at each gas-solid interface surface.