Glass Processing Lectures 17 and 18
Silica Glass Processing Parts 1 & 2
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Classroom Exercises

Lecture 17

1 - We just saw examples of how impurities such as water and alkali oxides can affect viscosity and optical transmittance of silica glass. Think of some other properties of silica glass and how different impurities might or might not affect them.

2 - We have talked about how the high melting point of cristobalite (the most refractory crystalline form of silica) and the high viscosity of the melt at that temperature makes traditional glass melting methods impractical or impossible to use for silica. Considering what you already know about traditional glass forming processes, which of them do you think could or could not be applied to silica glass? Why or why not?

3 - From what we have covered today, explain why the amount of water dissolved in silica glass differs between Type I and Type II. Which one is greater? Why? Would you expect that trend always to be the case? Why or why not?

Lecture 18

1 – Comparing the flame fusion process (Type II silica) and the flame hydrolysis process (Type III), what is the primary reason one yields glass having fewer metal oxide impurities than the other? (Metal oxide impurities means cations other than silicon.)

2 - Do you agree the two-step soot re-melting process does not fit either the Type III or Type IV classification? Why or why not? Should it have a classification of its own other than Type IVa?

3 – For any one of the applications discussed (not including optical fiber), explain why no other glass composition, oxide or otherwise, is likely meet the requirements. You may base your answer on physical properties or other factors.

Homework Questions

If a manufacturer advertised a high-silica glass having less than 100 ppm metallic impurities and about 1,000 ppm OH (dissolved water), what type classification would it be and how was it most likely manufactured?

Based on what you already know, or learned from these lectures, about optical fiber processing, which of the three methods, OVD, IVD or VAD, would be easiest to scale up for high volume manufacturing?

Multiple Choice
(Only one answer is correct.) If in doubt, state the reason for your answer.

1 – When water (H_2O) is incorporated into silica glass during processing

A – It physically dissolves into interstices (open spaces) in the glass network.
B – It reacts with the SiO_2 network to produce non-bridging oxygen bonds.
C – It decreases the visible light transmission of the glass.
D – It increases the upper use temperature of the glass.

2 – Silica glass made by flame fusion type processes tend to contain more dissolved water than those made in electrically heated furnaces because

A – They do not reach as high temperatures during processing.
B – Fuel combustion generates water vapor that can dissolve in the melt.
C – Electrical heat absorbs water from the melt.
D – They use raw materials that naturally contain water.

3 – Silica glass made in the 19^{th} and early 20^{th} centuries tended to be translucent or opaque because

A – The quartz crystals from which they were melted were opaque.
B – Air became trapped between the crystals as they melted and fused together.
C – The quartz crystals did not melt, so the glass was really crystalline.
D – The glass devitrified (crystallized) as it cooled.

4 – In a flame hydrolysis process, the silica soot particles

A – Form when the vapor impinges on the hot surface of the boule.
B – Form in the burner flame.
C – Crystallize in the burner flame, but melt when they reach the boule surface.
D – Always spread out smoothly (flow) on the surface where they land.

5 – The two-step (soot re-melting) flame hydrolysis process

A – Is preferable to the one-step (Type III) process for incorporating dopants more volatile than silica, such as B_2O_3 and P_2O_5.
B – Cannot make pieces more than a few inches in diameter.
C – Must always use an oxygen-hydrogen burner, not a natural gas-oxygen burner.
D – Introduces impurities, such as chlorine, that Type III processes avoid.

6 – Silica glass is an excellent material for making astronomical telescope mirrors because it

A – Is transparent and has a low thermal expansion.
B – Has a low thermal expansion and can be given an excellent surface polish.
C – Is transparent and can be given an excellent surface polish.

D – Can be made in large pieces and is transparent.

7 - Many microlithography stepper cameras used in the semiconductor IC (integrated circuit) industry have fused silica lens components because silica

A – Has excellent UV (ultraviolet) transmission and good thermal stability.
B – Has a high level of dissolved water and excellent IR (infrared) transmission.
C - Can be given an excellent surface polish and cannot be broken.
D – It absorbs excimer laser light.

8 – High purity synthetic silica glass products tend to be more expensive than those made from more common glasses because

A – The raw materials are in scarce supply.
B – The fuels used are unusual and expensive.
C – The rate of production (pounds per hour) is low.
D – Customers generally have unrealistic quality demands.

True or False?

1 – Silica glass is sometimes mistakenly called quartz because it has the same chemical composition as quartz and is often made by melting natural quartz crystals.

2 – While silica glass can be made quite pure, the impurities present will depend on the source of the materials from which it is made and the process by which it is made.

3 – Water at concentrations greater than 1 wt.% may be present in silica glass made by some of the processes we have studied.

4 – The upper use temperature of a piece of silica glass (the temperature at which it will deform under load) has little relationship to its viscosity at the processing temperatures nor to the method used to manufacture it.

5 – Small quartz crystals are sometimes melted under vacuum to help prevent air from becoming trapped between them and thus minimize bubbles in the final product.

6 - The flame hydrolysis process for making Type III silica glass always generates environmentally unfriendly HCl and CO_2 gases.

7 – Sol-gel process use higher temperatures than any other processes we have studied.

8 – High quality silica glass for use in high temperature electric lamps can be continuously drawn as tubing from a vertical electrically powered melting unit.

9 – Silica glass is used for the space shuttle windows because of its excellent thermal shock resistance and strong absorption of UVA and UVB wavelengths (wavelengths between 280 and 400 nm).

10 – Silica glass is an important component in automotive and stationary engine catalytic converters.

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