

University of Virginia

Department of Physics

Physics 606: How Things Work II

Lecture #35 Slides:

Knives and Steel II

and

Windows and Glass

Steel and Carbon 2

- Adding carbon to steel can harden it (less slip)
- Steel hardness also depends on heat treatment
 - Heating above 723 C, then slow cooling
 - Allows large iron carbide crystallites to form
 - Allows large ferrite crystals to experience slip
 - Softens the steel
 - Heating above 723 C, then rapid cooling
 - Produces tiny iron carbide crystallites
 - Strongly impedes slip
 - Hardens the steel

Stainless Steel

- Adding chromium (18%) and nickel (8%) makes stainless steel – resistant to most chemical attacks
- 18-8 Stainless steel is austenite
 - Dissolves carbon well
 - Can't be hardened by carbon or heat treatment
 - Nonmagnetic
- Better stainless steel is hardened by alloying
 - Alloy steels use extraneous elements to distort crystals
 - Distorted crystals can't slip easily

Windows and Glass

Question:

Which window of a car can tolerate the larger stress before breaking?

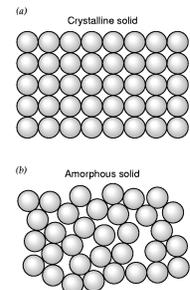
1. The front windshield
2. The side window
3. They're equally strong

Observations About Windows

- Windows are clear, but window glass looks greenish
- Window glass breaks if you heat it too rapidly
- Some older windows aren't very smooth
- Some car windows break into tiny pieces
- Window glass can be bent if you heat it carefully

Glasses

- Amorphous solids
- No crystal structure
- No long-range order
- Resemble “frozen liquids”

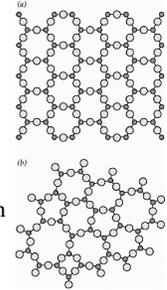


Forming a Glass

- Requirements
 - Material must have high viscosity at melting point
 - Material must have difficulty nucleating crystal
- Procedure
 - Melt material to eliminate crystal structure
 - Cool material quickly through melting temperature
 - Form supercooled liquid
 - Cool until solid

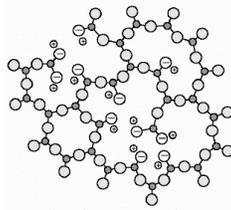
Quartz

- Quartz is silicon dioxide (silica)
- Is an excellent network former
 - Slow cooling forms regular network
 - Fast cooling forms irregular network
- High viscosity at melting point
- However, nucleates crystals easily
- Melting point of Quartz is very high



Soda-Lime-Silica Glass

- Adding sodium oxide (soda) lowers melting point
- Adding calcium oxide (lime) makes it insoluble
- Sodium and calcium ions terminate the network and soften the glass
- Soda-lime-silica glass is common glass



Borosilicate Glass

- Soda-lime-silica glass expands much when heated
 - Breaks easily during heating or cooling
- Boron-oxide-silica glass expands less
 - Tolerates heating or cooling reasonably well
- Pyrex and Kimax are borosilicate glasses