

The page, which you have just visited, was created for students of **Faculty of Materials Science and Ceramics**. But it could be very useful for these, who are interested in Glass Technology and some physical phenomena, which have taken place in this interesting material. The way of presentation the following information is very clear and dense even for the people, who are not involved in this subject-matter. The lectures and laboratory classes of “Glass Technology and Amorphous Coatings” were the source of information and our creative inspiration, respectively.

Prof. dr hab. inż. Jan Wasylak and dr inż. Manuela Reben, are the supervisors of the page. We would like to thank them for their kindness and for helpful comments on the text.

Some information about this page

There are III main topics in the menu, which are introductions to applied sections. Each of them are divided into the parts, described the define phenomena and the ways of its investigation. Furthermore, there are short test in the annex, which could be very useful to review and check the state of knowledge.

There are also special version for the printout.

We hope that our page will fulfill its assumption data and will be helpful teaching aids for all visitors.

Please vote 😊😊😊

### *Historical sketch*

The ability of fusing, making and producing glass is a thousands years old. We do not know, who, where and when, had made such a extraordinary material, called glass. But over a five thousands years, this material have been admired a mass of people. *Rajmundus Lullus*, the alchemist from XIII century called glass „the first product philosophy of chemistry”.

Glass plays an essential role in science and industry, glass is a part of our everyday lives. The glass is the world's oldest artistic product, The oldest glasses in world were discovered by archeologys, and nowadays everybody can admire them in musems in the whole world . The first glasses were colorful. At the beginnig of glass-making in Assyria and Egypt there were only colorful glasses, especially green, blue (turquoise), red (coppery), brown, white (stirred) and of course black in every possible shade. The row materials were mainly the substance consisted of elements like: **Fe, Mn, Cu, Sn, Co, Ni**, and the others strong dyes. From the acient times to the the present days, colorful glasses and optical glasses have been study in every possible way.

### I. Introduction. What does the glass mean?

Matter is a general term for the substance of which all physical objects are made however in practice there is no single correct scientific meaning; each field uses the term in different and often contradictory ways. As we know, matter is existed in four states (or phases): solid, liquid, gas and plasma.

#### Solid

There is still much about the molecular physics and thermodynamics of glass, that is not well understood, but it could give a general account of what is thought to be the case.

Many solids have a crystalline structure on microscopic scales. The molecules are arranged in a regular lattice. Usually when a liquid is cooled to below its melting point, crystals form and it solidifies. But sometimes it could become *supercooled* and remain liquid below, its melting point because there are no nucleation sites to initiate the crystallisation. If the viscosity rises enough as it is cooled further, it does not crystallize. The viscosity rises rapidly and continuously, forming a thick syrup and eventually an amorphous solid. The molecules then have a disordered arrangement, but sufficient cohesion to maintain some rigidity. In this state it is often called an amorphous solid or easily and commonly glass. There is a conviction, that glass is actually a supercooled liquid because there is no first order phase transition as it cools.

### The definitions of glass

The classic definitions of glass is based on the historical methods of formation. This way is very unique of defining any material. The result of such a treatment is that, the glass is defined by several different versions.

Glass is a solid that does not show long-range order

Glass is a liquid that has lost its ability to flow.

A solid assembly of vertex-sharing tetrahedra lacking long range-order.

But furthermore there are also definitions

**Glass** is an amorphous (non-crystalline) solid material which in the temperature  $T_g$  (the vitrification temperature) has got a viscosity equal  $10^{13}$  dPa·s and does not have long-range order of molecules, atoms etc.

### **The definition of glass by U.S. National Research Council**

Every substance which is an amorphous (non-crystalline) solid material

Glass has got a identical values of a property in all crystallographic directions and is called a isotropic material.

Molecules of a glass are disordered but are rigidly bound.

### II. Optical properties of glass

As we know glass is very interesting materials with useful properties such as:

- ✓ glasses are among the few solids that transmit visible light
- ✓ glasses form the basic elements of virtually all optical systems
- ✓ world-wide telecommunications by optical fibers
- ✓ aesthetic appeal of fine glassware- 'crystal' chandeliers
- ✓ high refractive index/birefringent PbO-based

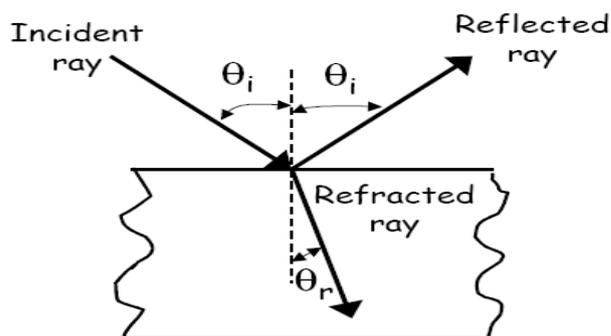
The most common optical properties are:

1. Bulk Properties: refractive index, optical dispersion
2. Wavelength-dependent optical properties: colour
3. Non-traditional, 'induced' optical effects: photosensitivity, photochromism, Faraday rotation

*1. Refractive Index~(velocity of light in vacuo, or air)/(velocity of light in medium)*

Snell's Law:

$$n = \frac{\sin \theta_i}{\sin \theta_r}$$



*Internal Reflection:*

Critical angle (Brewster's angle  $\theta_c$  below which light is totally reflected):

$$\sin \theta_c = \frac{1}{n}$$

- ✓ larger  $n$  means greater  $\theta_c$ , and so more light (from a broader distribution of incident angles) will be internally reflected. High index materials (diamonds, PbO glasses) look 'brilliant' when facets are cut so that internal reflection returns light from large faces that originally collected the light.
- ✓ internal reflection is important for transmission of light down an optical fiber.

2. There are different kind of perceptions such as:

- ✓ Scotopy – based on the activity of rods; high sensitivity, lack of seeing colour, see contour of the objects,
- ✓ Photopy – based on the activity of rods and cone cells

What is colour?

Physical specifications of colour are associated with objects, materials, light sources, etc., based on their physical properties such as: light absorption, reflection, or emission spectra.

Colour is the perception, based on the varying sensitivity of different types of cone and rods cells in the retina to different parts of the spectrum. Colours can be defined and quantified by the degree, which they stimulate such a cells

Colour in glass is result of:

- ✓ Selective absorption
- ✓ Scattering of specific visible wavelengths

Below there are some mechanisms lead to colour in glasses:

- ✓ Absorption based on electron transitions, ligand field theory
- ✓ Light scattering- takes place in colloidal metals and semiconducting particles
- ✓ Photosensitive
- ✓ Fluorescence

### 3. Optical glasses

Optically transparent materials focus on the response of a material to incoming light waves of a range of the wavelengths. Often selective optical filters can be utilized to alter or enhance the brightness and contrast of digital images. Guided light wave transmission via frequency selective waveguides involves the emerging field of fiber optics and the ability of certain glassy compositions as a transmission medium for a range of frequencies simultaneously (multimode optical fiber) with little or no interference between competing wavelengths or frequencies.

An optical fiber is a dielectric waveguide which transmits light along its axis by the process of total internal reflection. The fiber consists of a core surrounded by a cladding layer. To confine the optical signal in the core, the refractive index of the core must be greater than that of the cladding. The index of refraction is a way of measuring the speed of light in a material. The larger the index of refraction, the more slowly light travels in that medium. Typical values for core and cladding of the optical fibers are 1.48 and 1.46.

Optical waveguides are used as components in integrated optical circuits (in light-emitting diodes, LEDs) or as the transmission medium in local and long optical communication systems. Also of value to materials science is the sensitivity of materials to thermal radiation in the infrared (IR) portion of the EM spectrum. This infrared homing capability is responsible for such diverse optical phenomena as "night vision" and IR luminescence.

### *III. Fusing glass for optoelectronic*

For fusing glass was used only pure chemical resources of pure level cz.d.a. The melting process was lead in a platinum crucible with the platinum lid. Such a kind of crucible is used to get a glass of high pure level. The glass was fusing in 1450°C in the electric oven. And next, the glass was poured out in the metallic plate. The glass had been relaxing in 530°C for 12 h, cooling to get a room temperature.