212038 – VITREOUS MATERIALS

CREDITS: 02 (two) – 30 hours/class

CONTENT:

The vitreous and amorphous states of inorganic substances. Thermodynamics and the vitreous state. General approximations in the structural description of glasses. Nucleation and crystalline growth in glasses. Fundamental methods for investigating the structure of non-crystalline solids.

SYLLABUS:

1. The vitreous and amorphous states of inorganic substances: methods for preparing amorphous solids and glasses: glasses obtained from the molten material (oxides, fluoride glasses, chalcogenite glasses, metal glasses, variation of the cooling rate in glass forming liquids); amorphous materials obtained in solutions (precipitation of gels, amorphous precipitates, electrolytic deposition of amorphous films); amorphous films obtained from gaseous phases (vacuum thermal evaporation methods - chemical vapor deposition); transformation of crystalline solids into amorphous phases (mechanical processes, irradiation, shock waves, chemical reactions).
2. Thermodynamics and the vitreous state: The vitreous state: the first attempt to classification. Basic thermodynamic relations: the fundamental laws of classical thermodynamics and some consequences; the criterion of thermodynamic evolution, conditions of stability and the thermodynamic description of states out of balance; phases and phase transformation. Crystallization, vitrification and devitrification of glass forming liquids. The viscosity of glass-forming liquids. Thermodynamic properties of glass forming liquids. The glass transition temperature: determination methods; Tg and thermal expansion, Tg and thermal capacity; Tg and the melting temperature; trend of glass formation; thermodynamic functions and the glass transition, the Kauzmann paradox. Conclusions: the nature of the vitreous state.
3. General approximations in the structural description of glasses: Goldschmidt rule. Zachariasen criteria for the formation of glasses. Lebedev's crystalline hypothesis for the glass structure. The Bernal-Polk model. Voronoi polyhedra, polymerization and aggregation.
4. Nucleation and crystalline growth in glasses: kinetics of homogeneous nucleation: classical theory of nucleation. Heterogeneous nucleation: ways of inducing crystallization; basic thermodynamic relationships; the kinetics of heterogeneous nucleation. Kinetics of general crystallization: the Kolmogorov-Avrami equation; experimental results; kinetic criteria for the formation of glasses.
5. Fundamental methods for investigating the structure of non-crystalline solids: Thermal methods (DSC/DTA). Diffraction methods: X-rays, neutrons, electrons. Raman and Infrared Spectroscopy. X-ray absorption spectroscopy (EXAFS).

BIBLIOGRAPHY:

1. VARSHNEYA, Arun K. Fundamentals of inorganic glasses. Academic Press, 1993.
2. SCHMELZER, Jurn W.P. et al. Glasses and the glass transition. Wiley-VCH, 2011.
3. SHELBY, James E. Introduction to glass science and technology. 2.ed. Royal Society of Chemistry, 2005.
4. GUTZOW, Ivan S.; SCHMELZER, Jurn W.P. The vitreous state: thermodynamics, structure, rheology, and crystallization. Springer, 1995.