Manipulating the Range of Glassy States: Methods beyond Traditional Quenching

Jiri Orava

Faculty of Environment, J. E. Purkyne University in Usti nad Labem, Pasteurova 3632/15, Usti nad Labem 400 96, Czech Republic (jiri.orava@ujep.cz)

Metallic glasses (MGs) are of fundamental and technological interest because of their large reversible elastic energy storage (this interesting property of MGs will be demonstrated during the lecture), high hardness giving good wear resistance, and high toughness, which can be combined with other properties such as low-loss soft-magnetic properties, biocompatibility as (non)-degradable implants, or biomimetic functionality. A range of isoconfigurational glassy states, potential energy, exceeding 17 orders of magnitude can be achieved upon cooling a liquid, but a range of about 6–7 orders of magnitude is accessible by conventional melt-quenching techniques. Highly relaxed glassy states, close to that of crystal, are possibly achieved for some thin-film ultra-stable glasses, while highly-unrelaxed states can readily be studied by computer simulations. The available enthalpy change is about 90% of that of enthalpy of melting. Such a wide range of states available gives access to a broad range of properties which can be tuned by controlling the glass energy. In the lecture, we will introduce some of the fundamental properties of MGs and show their relevance for different technologies.

Unlike their unique elastic properties, MGs suffer from poor plasticity which limits their applications as structural materials. There are many ways the deformability of MGs can be improved, such as via thermal cycling, thermomechanical processing, surface imprinting, free-volume control etc. All methods rely on suppressing shear bands nucleation and their propagation to avoid catastrophic failure of MGs upon mechanical deformation. In the lecture, we will focus on describing the formation of MGs—crystal composites to enhance the MGs deformability. We will show that a combination of complementary *in-situ* high-energy X-ray diffraction, *in-situ* XRD combined with containerless solidification during electromagnetic levitation, *in-situ* transmission electron microscopy and flash calorimetry is powerful to understand metastable phase formation, beneficial to the plasticity, in MGs with heating rates up to 10^5 K s^{-1}.

By exploiting the knowledge of crystallization, we will demonstrate the biomimetic properties of MGs. By using laser patterning, magnetic leaves formed of MG, mimicking the responsiveness of touch-sensitive plants such as *Mimosa pudica*, can be fabricated. Therefore, inspired by nature, we will try to understand how nature solves or exploits some of the fundamental properties and limitations noted above.