Description for the general public

One of the most intriguing ideas during the last decade in materials' science are materials stabilized by the high configurational entropy of the system. The first materials of such type were the high-entropy alloys (HEAs), which have been intensively developed from 2004. However, since then this concept has been successfully applied to nitride systems (high-entropy alloys nitrades - HEANs) and, during last two years, to borides (high-entropy metal diborades - HEBs) and oxides (ang. high-entropy oxides - HEOx). Especially this last group has caught the attention of scientific community, as the materials exhibit extremely desirable electrical properties.

The first high-entropy oxide was synthesized back in 2015. Materials from this group, similarly as in the case of high-entropy alloys, usually exhibit structure of solid solution. Stabilization of such structure is possible thanks to the high number of components (usually 5 or more). This leads to the random distribution of the elements in the whole crystal lattice. As a result, a number of new properties is generated in the system - properties which are different from the ones characterizing each, single components. This concept is radically different from the one used in conventional materials, in which the properties of the materials are dictated by properties of one or two main components. In 2016, for the first time a feasibility of doping of equimolar (Co,Cu,Mg,Ni,Zn)O high-entropy oxide was tested. A number of ions characterized by different valence was examined. The results obtained for the sample doped with lithium exceeded all expectations. It turned out that the ionic conductivity of the modified material considerably exceeds the values measured in currently used solid electrolytes. Considering the fact that solid electrolytes are an essential technology for the development of Li-ion batteries, applied in a vast number of mobile electronic devices, it is obvious that HEOx materials may have a huge future ahead of them. However, as of today, a complete lack of data considering doping of new HEOx compositions and structures is observed. Also, the theoretical basis of the ion conductivity mechanisms are still not explored. Such state of our knowledge does not allow assessing correctly the capabilities of theses materials in a role of solid electrolytes.

The main objective of the proposed project is to study the influence of the alkali dopants (Li, Na, K) on the microstructure, thermal stability and electrical properties of the high entropy oxides. The choice of base materials will be based on the most recent developments in the field of HEOx materials. The original input of the research team will be determining of the previously ignored dependence of HEOx structures on the oxygen partial pressure. To characterize the materials, a number of novel experimental techniques will be applied, what will allow understanding of the relations between chemical compositions, structures and electrical properties of high-entropy oxides. Such a comprehensive approach should greatly expand our current state of knowledge and understanding of the HEOx materials, leading to their much faster development in future and allowing to design the materials of the desired properties in a much more effective manner. Hopefully, the results may also form a foundation, on which a new generation of HEOx-based solid electrolytes can be developed.