Exploring novel materials by high pressure and ceramic combinatorial solid state chemistry

Nikolai Zhigadlo

Department of Chemistry and Biochemistry, University of Bern, 3012 Bern, Switzerland

In this talk I will provide new insights into the materials synthesis and characterization of modern superconducting materials. Two different approaches such as the high-pressure, high-temperature method and ceramic combinatorial solid state chemistry will be presented with application to several typical compound classes.

First, I will review the high-pressure exploration of the Mg-B-N system. Here, by crystal growth we prepared two completely different types of materials: a rare two-band superconductor MgB_2 and a wide-band semiconductor hBN. Besides interesting physics, both of these materials hold great potential for practical applications.

Successively, I will highlight the key role of extreme conditions in the growth of Fe-based superconductors, where a careful control of the composition-structural relations is vital for understanding of the physical behavior. The availability of high-quality LnFeAsO (Ln1111) single crystals allowed us to measure intrinsic and anisotropic superconducting properties.

Then, I will further emphasize the beneficial role of the high-pressure, high-temperature conditions in exploring the crystal growth of various intermetallic superconductors, such as $MgCNi_3$, Mo_3Al_2C, and $SrPt_3P$. The underlying correlations and the general trends between composition, structure and superconductivity in these materials will be discussed.

Finally, I will demonstrate that combinatorial ceramic solid state chemistry is an efficient way to search for new oxide superconductors. A single sample synthesis concept based on multi-element ceramic mixtures can produce a variety of local products. Such a system needs local probe analyses and separation techniques to identify compounds of interest. We present the results obtained from random mixtures of Ca, Sr, Ba, La, Zr, Pb, Tl, Y, Bi and Cu oxides reacted at different conditions. By adding Zr but removing Tl, Y, and Bi the bulk superconductivity reached a T_c as high as 125 K.