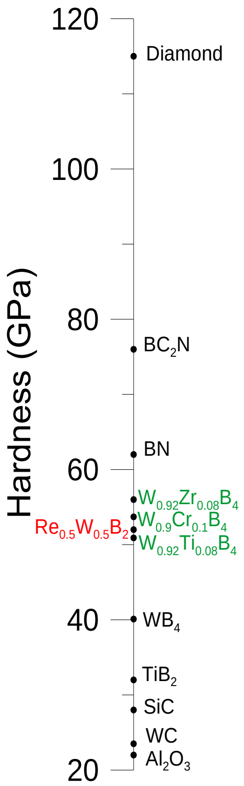

Figure 1

During latest years the transition metal borides due to their combination of outstanding physical properties such as electric and thermal conductivity comparable with metals, high incompressibility, high shear strength, and exceptionally high hardness have attracted attention amongst materials researchers. All of these attributes are desirable in materials for structural and engineering compounds and could indicate that borides may be suitable replacements for currently used metal carbides in next-generation cutting tools. Therefore, when ReB_2 was first shown to be super-hard at low loads (H_v= 40.5 GPa), the results were heralded as a breakthrough in hard materials. At the same time, it was clear that ReB_2 would be less likely to result in a practical system because of the high cost of Re and fast corrosion. Tungsten borides are a comparatively low-cost materials, and the data from recent investigations show that it can be converted to a material with significantly higher hardness than ReB_2 by the addition of small amounts of relatively low-cost elements. Also the increasing industrial demand for protective coatings with high hardness, good elastic properties and thermal stability calls for the investigation of new material systems. The proposed by us project represents a significant step forward in the search for low-cost, easily manufactured hard materials also in the form of protective coatings. This project concerns study of new super-hard materials as tungsten borides WB, WB_2, WB_4 doped by Rhenium, Titanium, Zirconium, Molybdenum and Chromium. Those are the most interesting structures of ternary borides, because their hardness should significantly increase in comparison with WB_x. For example hardness of $W_{0.92}Zr_{0.08}B_4$ is 55.9 ± 2.7 GPa when WB_4 is only 40 GPa (fig. 1 - red color indicated the compound obtained during the preliminary tests). The coatings will be deposited by magnetron sputtering method or pulsed laser deposition (PLD) using sputtering targets of doped tungsten borides having a different molar ratio of Re, Ti, Zr, Mo, Cr to tungsten. Also hybrid method that involves the use of two magnetrons or laser and magnetron is planned where the first target will be made from tungsten borides and second from dopant. The targets will be made by spark plasma sintering (SPS) methods. Coatings will be deposited in a vacuum chamber on Si substrates, and to check application possibilities also on tool steel. We propose also numerical prediction of structural, mechanical properties of these compounds. The examination of targets and deposited films together with theoretical investigation of structures and processes occurring during deposition should lead to determination of conditions necessary for formation of reliable, super-hard coatings – the ultimate goal of the project.

It should be stressed that this will be a first systematic study of various compounds of ternary tungsten borides in the form of thin films, uniting the deposition parameters, internal structure of the material, and its functional properties. The modern research techniques will be used to investigation of properties of deposited coatings. The surface roughness will be measured by an atomic force microscope (locally) and microscopic optical profilometer (globally). The internal structure of materials and determination of the type of formed chemical compound will be studied by X-ray diffraction and transmission electron microscopy. For well characterized coatings will be examined the mechanical and chemical properties such as hardness, fracture toughness and thermal stability. The hardness and fracture toughness will be tested in a nanoindentation test. The thermal stability of the coatings will be studied in depth on the basis of changes in the structure of the material after annealing at temperatures of from 300 to 1000 ° C. For structural calculations DFT method will be used. In Figure 2 an exemplary theoretical structure of $Re_{0.52}W_{0.48}B_2$ is shown.

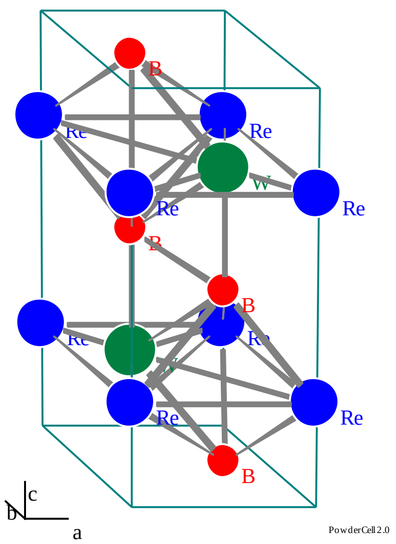

Figure 2