Machine parts, as knives, blades of gas turbine engine parts and related components operating at high friction or in a hot, corrosive environment due to their intended purpose are exposed to the degrading agents like abrasion, high temperature and corrosive enviroment. The quality and reliability of these components is provided by the material properies, therefore, there is still increasing demand for materials having excellent physical and chemical properties. Unfortunately, the price of such materials is high, increasing the cost of production. Currently, this problem is often solved by use of cheaper material, e.g. steel and susbsequent deposition of coatings with better properties. Among the materials deposited as a coating, the super-hard materials play a significant role. They are used for the protection of surfaces from mechanical damage, providing corrosion protection as well as thermal stability.

Currently, the most widely used super-hard materials are diamond and cubic boron nitride (c-BN). Unfortunately diamond at high temperatures undergoes graphitisation and loses its super-hard properties. Moreover, use of diamond in machining of steel is restricted, because it reacts with iron. In turn, boron nitride demands very high pressures and temperatures in the process of its production. That is why it is so important to find a material that could be an alternative to diamond and c-BN.

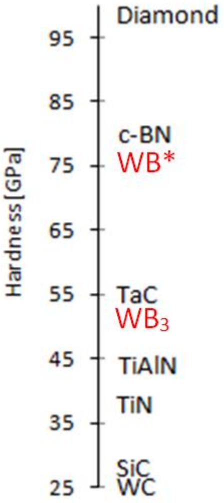

Fig. 1. Hardness of selected materials
* own results

In this project a group of super-hard tungsten borides whose properties can be comparable with the diamond and c-BN is presented [7]. The most important advantages of tungsten borides are high thermal stability, high chemical resistance and relatively low cost of manufacturing due to the possibility of sintering at atmospheric pressure. The theoretical hardness of tungsten borides is significantly higher than hardness of widely used hard materials such as tungsten carbide (WC), corundum (Al_2O_3), silicon carbide (SiC) or titanium nitride (TiN). Tungsten borides belong to the group of transition metal borides, which hardness is a result of advantageous combination of transition metal such tungsten with a light element- boron. Tungsten borides are characterised by a high density of valence electrons derived from metals and short strong covalent bonds of boron. Compounds of tungsten borides synthesised till now (W_2B, WB, WB_3, WB_4 [3-6]) confirm the high hardness of the material. However, the most interesting feature of tungsten borides is very high hardness when they are in the form of thin coatings. The coatings of this type (WB_3, WB_4 [4-6]) can be called super-hard, because their hardness exceeds 40 GP. Preliminary tests conducted in our laboratory show that coatings of tungsten borides can achieve hardness comparable even with diamond-like coatings and c-BN (Fig. 1). Such attractive results are related to the microstructure (grains size and distribution) of these coatings.

The aim of this project is to produce and to study properties of coatings from tungsten borides coatings such as WB, WB_2 and WB_3. These are the most interesting structures of tungsten borides, because their theoretical hardness should significantly differ among them, but preliminary studies show that all of them exhibit similar hardness exceeding those resulted from theoretical calculations. The coatings will be deposited by magnetron sputtering method using sputtering targets of tungsten borides having a different molar ratio of boron to tungsten. This method is based on sputtering of target atoms to condense on the substrate as a thin layer [8]. Magnetron sputtering enables effective control over the structure of material at the level of atoms and molecules. By modifying the parameters of deposition, such as sputtering power, pressure and kind of working gas and the temperature of the substrate, the control of the microstructure and obtaining of nano-grain material will be possible. This is important because by forming the internal structure can be improved the mechanical properties of the material such as hardness or fracture toughness. Moreover, the magnetron sputtering allows high production repeatability.

The properties of the coatings will be examined by modern research techniques. The surface roughness will be measured by an atomic force microscope (locally) and microscopic optical profilometer (globally). The internal structure of coatings and the type of chemical compound will be studied by X-ray diffraction and transmission electron microscopy. For well characterised coatings the mechanical and chemical properties such as hardness, fracture toughness and thermal stability will be examined. 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 in range from 300 to 1000 ° C.

This project will be a first systematic study of coatings of various tungsten borides, covering the deposition parameters, internal structure of the material, and its functional properties. Its implementation allows to the selection of tungsten borides layers having the best functional properties and the evaluation of their functionality.