

Tools for machining, and wear-resistant parts are important for modern industry. Growing requirements pose new challenges for materials scientist in field of hard, and superhard materials. Protective coatings are used for a majority of tools and parts. Nitrides, carbides, and oxides deposited on wide range of details can significantly improve their resistance to friction, and increase their application potential. Superhard films, like diamond and cubic boron nitride, have even better results in increasing performance, and durability of such tools. However, they possess drawbacks that significantly reduce their application potential – affinity to ferrous materials, and weak adhesion to some substrates. An alternative for common superhard materials can be superhard tungsten borides with addition of different transition metals. Additional major aspect is coefficient of friction of these materials. In case of borides the most novel observations shows that material of this group can achieve superlubricity. Although hard, and superhard coatings can significantly improve tools, and parts, it is known that increasing the loads on such details can significantly limit their durability. It is caused by lack of mechanical support of softer than coating substrate. To challenge this issue surface of substrates can be hardened prior to deposition of protective films. Such procedure is usually called a duplex treatment. Nitriding, carburizing, and quenching was successfully used prior to deposition of hard, and superhard materials. Therefore, it is highly reasonable to use the same approach for superhard tungsten borides.

In this project it is proposed the high power impulse plasma nitriding of steel prior to deposition of tungsten-transition metal boride $(W,TM)B_2$ ($TM = Nb, Ta$) by high power impulse magnetron sputtering (HiPIMS). Both of this technique works in similar pressure conditions, therefore they can be used in same vacuum chambers. Plasma nitriding nitriding is a low-temperature technique with good control of microstructure obtained during the process. This is an important issue prior to deposition of hard, and superhard coatings – in case of gas-nitriding, nitride zone needs to be removed before the deposition, while plasma nitriding can produce hard diffusion layers without nitrides zone. HiPIMS technique in comparison to traditional magnetron sputtering can produce coatings with much better quality in lower temperature. Deposition temperature is important because it can led to unwanted microstructure changes of substrate.

The aim of the project is to produce and characterize the microstructure, and properties of **superhard and superlubricant** tungsten-transition metal borides deposited on high power impulse plasma-nitrided steels. Current studies shows that using these two techniques can give good results, and increase the performance, and durability of tools, and parts. Preliminary studies shows that by employing these two techniques for deposition of tungsten-niobium borides $(W,TM)B_2$ should be possible

Microstructure and properties will be examined by wide range of techniques, such as scanning electron microscopy SEM, X-ray diffraction XRD, Vickers hardness tests, nanoindentation tests, scratch-test, wear-test. Additionally, novel technique of micro-cantilever bending made by focus ion beam FIB will be used to evaluate the fracture toughness of obtained layers, and films.

Novel high power impulse plasma nitriding will be used in this project. Deposition of tungsten-niobium borides $(W,Nb)B_2$ will be performed first time in this project