O 1. Investigation of Wavelength Influence on Rhenium Diboride Films Prepared by PLD Method

J. Chrzanowska[1], J. Hoffman[1], M. Giżyński[2], T. Mościcki[1]

[1]Institute of Fundamental Technological Research of the Polish Academy of Science

[2]Faculty of Material Science and Engineering of Warsaw University of Technology

e-mail address: jchrzan@ippt.pan.pl

In answer to research interest in production of super hard coatings prepared by pulsed laser deposition (PLD) method, Rhenium Diboride was taken under consideration. PLD is characteristic by necessity to define deposition parameters best for particular substance. ReB_2 coatings were prepared with the use of 355nm and 1064nm wavelengths of Nd:YAG laser and the influence of laser wavelength on those films preparation was investigated. Deposition efficiency increased with shorter wavelength, however layer's smoothness was better for longer wavelength. The XRD analysis shows crystalline ReB_2 character of achieved samples.

1. INTRODUCTION

Rhenium Diboride is a hard material with a great perspective to manufacturing hard, wear resisted coatings, capable to increase of a tool life [1, 2]. Currently is being examined deposition of ReB_2 films by PLD method. PLD is providing the possibility of deposition materials of complex chemical composition and stoichiometry as well as manipulate of film's growth and create composite multilayer coatings. It is also characterized by the necessity of the selection of deposition characteristics such as laser pulse fluence and wavelength, target to substrate distance and substrate temperature [3]. Those parameters could drastically change mechanical and physical properties of thin films. This work presents a comparison of ReB_2 films prepared with different laser pulse wavelengths: 355nm and 1064nm, of the Nd:YAG laser.

2. METHODOLOGY

The targets used for pulsed laser deposition method were fabricated from Boron (~625 mesh, 99.7% purity, Sigma Aldrich) and Rhenium (~625 mesh, 99.9% purity, KGHM Polska Miedź) mixed in the molar ratio 2.5:1, sintered by the SPS Method [1]. Substrates were prepared by subsequent washing in acetone and ethyl alcohol in an ultrasonic bath. The ReB_2 thin films were deposited on a silicon substrate (Spi Supplies) at temperature of 570ºC [2] in vacuum ($2 \cdot 10^{-6}$ mbar). There were used a 54000 pulses at a repetition rate of 10Hz , pulse duration of 10ns and spot area of 3.5mm^2 of the Nd:YAG laser (Quantel YG 981 E10) with a target to substrate distance of 42mm.

The structure of the films were examined on XRD: Bruker D8 Discover (Cu radiation, λ=1.5418Å, laser power 1.6kW). The layer geometry characterization was carried out on a white- light interferometer Veeco NT1100 and the surface quality was subject to inspection under a SEM: Hitachi S-3500N. The Vickers hardness of the film was examined under instrumental nanoindentation tester CSM Instruments with Berkovich indenter and indentation load of 5μN.

3. RESULTS AND DISCUSSION

The film thickness as a function of laser pulse energy and films structure is shown in Fig. 1 and Fig. 2 respectively. Comparison of film's surfaces for different laser wavelengths and laser pulse power is shown in Fig. 3. It was confirmed that achieved film was composed by ReB_2, where shorter laser wavelength exhibit stronger 002 orientation. Surface structure and deposition efficiency strongly

depends on laser wavelength and pulse power. It is known that there is higher absorption coefficient of shorter wavelength, which for enough huge pulse energy might cause plucking of high energy droplets of the target material. When they reach substrate, they stick to the surface. There was also tested Vickers hardness of prepared films which was at a level of 60 GPa.

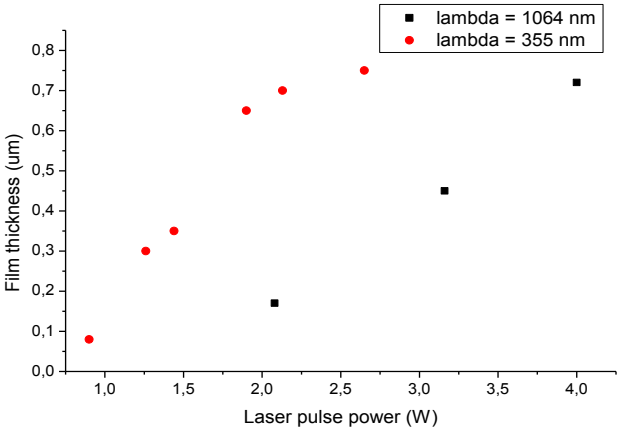

Fig. 1. Comparison of film's thickness for λ=355nm and λ=1064nm.

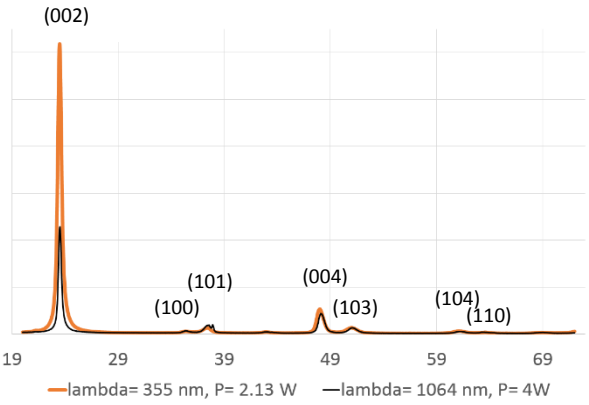

Fig. 2. Comparison of film's structure for λ=355nm and λ=1064nm

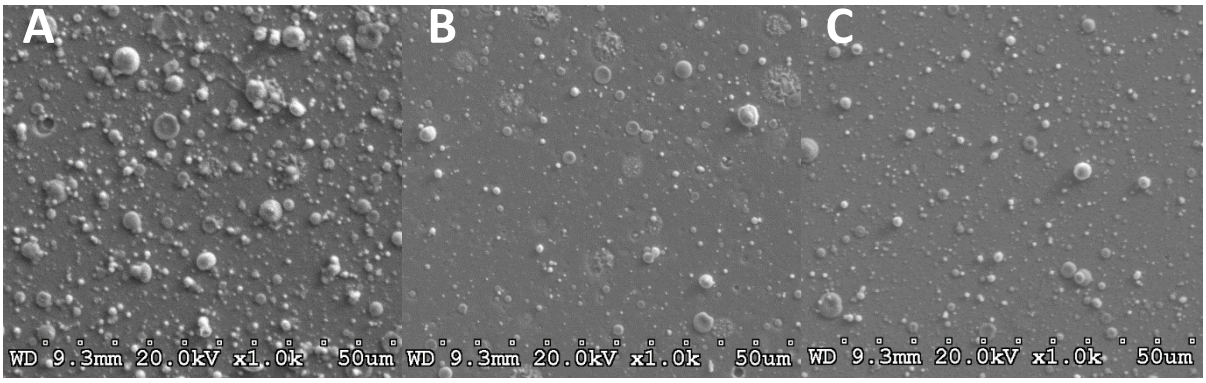

Fig. 3. Film's surface after PLD with A: λ=355nm and P= 2.13W, B: λ =1064nm and P=4W, C: λ=355nm and P=1.26W

4. CONCLUSIONS

ReB_2 coatings present notable hardness. Deposition efficiency for λ=355nm is around two times higher than for λ=1064nm. The use of shorter wavelength results in increase of number of droplets even for several times lower laser pulse energy. It is suggested to take under consideration particle filtration especially for shorter wavelengths.

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