Effect of boron dispersion phase content and heat treatment on the microstructure and mechanical properties of the Ni-B/B composite coatings

Katarzyna Skroban*, Grzegorz Cieślak, Tinatin Ciciszwili, Adrian Dąbrowski, Anna Gajewska-Midziałek, Marta Gostomska, Edyta Pęśko, Maria Trzaska

Łukasiewicz Research Network – Institute of Precision Mechanics, Duchnicka 3, 01-796 Warsaw, Poland

INTRODUCTION

This work is the result of a project that is part of the global search for materials that meet high operational requirements, such as high hardness, corrosion resistance and abrasive wear resistance. Produced coatings can be substitutes for chromium coatings, which corresponds to the goal of the European Union - the elimination of Cr(VI) compounds.

The paper presents the results of studies of composite coatings with Ni-B matrix and B particles as a dispersion phase produced by electroless deposition method.

EXPERIMENTAL

Composite coatings were deposited on a steel substrate using the dispersion phase of boron powder with the size of the particles under 1 µm by the chemical reduction method. The coatings were deposited from baths differing in content of the dispersion phase equal to 0.1; 0.5; 1.0 and 1.5 g/dm^3. The samples were heat treated (HT) at the temperature of 400ºC, in the air atmosphere, for 30 minutes.

Surface morphology and topography were examined using the scanning electron microscopy (SEM). The structure of the produced materials was defined using X-ray diffraction analysis. Thickness of the produced coatings was examined by light microscopy on cross sections of the samples and microhardness of the coatings were determined by Knoop method. Mechanical properties of the coatings were examined by Depth Sensing Indentation (DSI) method.

RESULTS

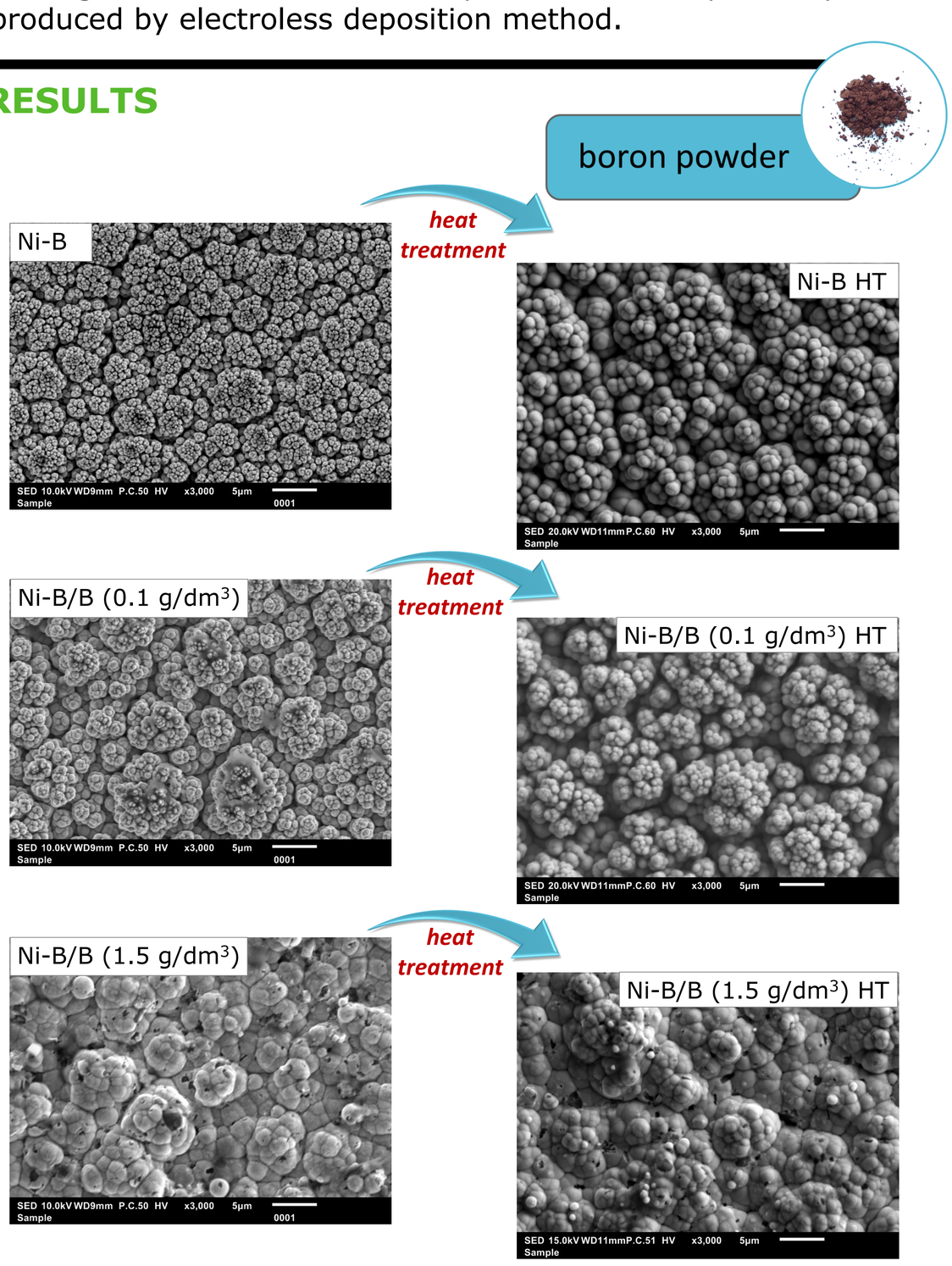

Fig. 1. SEM images of produced coatings before and after heat treatment

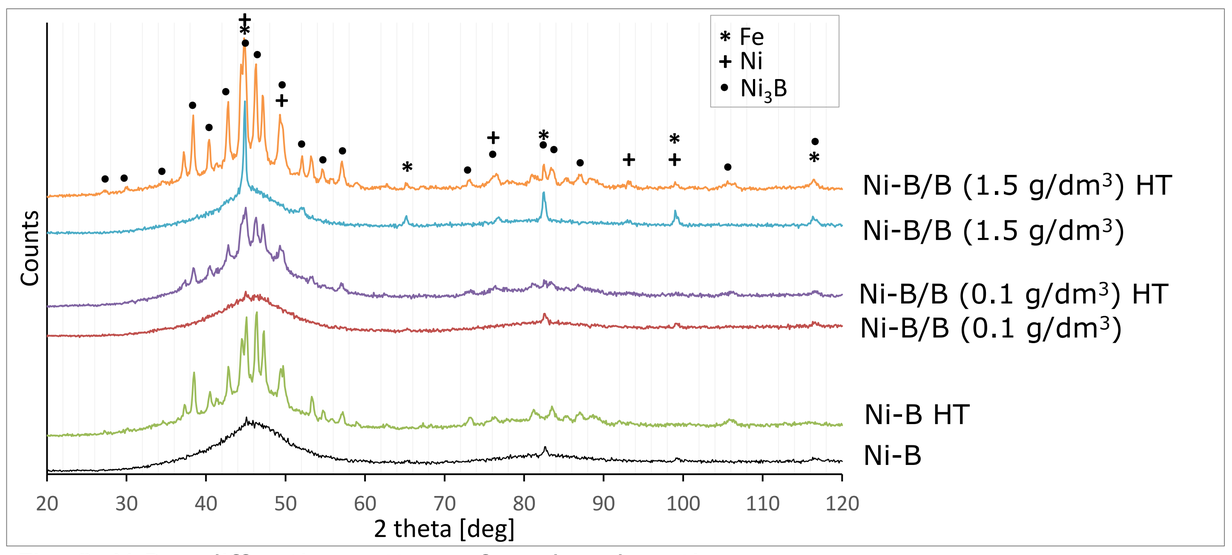

Fig. 2. X-Ray diffraction pattern of produced coatings

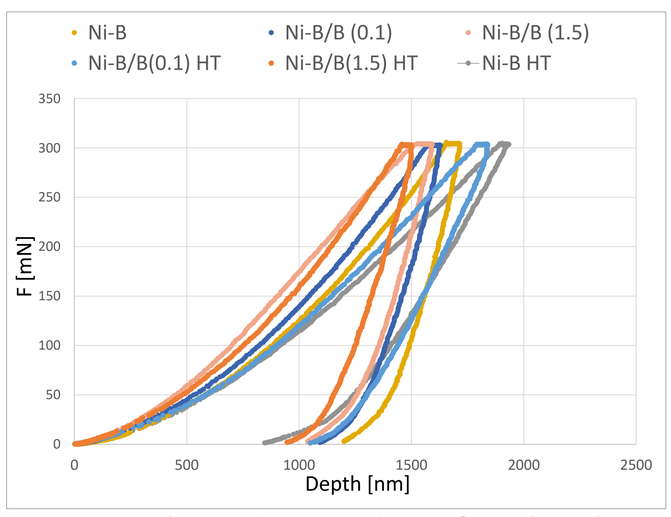

Fig. 3. Mechanical parameters of produced coatings before and after heat treatment

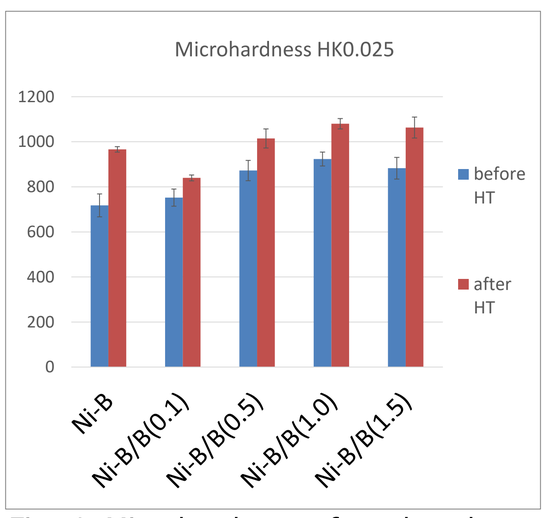

Fig. 4. Microhardness of produced coatings before and after heat treatment

Tab. 1. Thickness of produced coatings after heat treatment

Coating	Thickness [µm]				
	Ni-B	Ni-B/B (0.1 g/dm^3)	Ni-B/B (0.5 g/dm^3)	Ni-B/B (1.0 g/dm^3)	Ni-B/B (1.5 g/dm^3)
After HT	37.74	24.36	24.89	22.01	17.89

Tab. 2. Mechanical parameters of produced coatings before and after heat treatment

Coating	Microhardness		Elastic modulus E_{IT} [GPa]
	H_{IT} [MPa]	H_M [MPa]	
Ni-B	5454	3919	130
Ni-B HT	5735	3108	57
Ni-B/B (0.1 g/dm^3)	6194	4289	128
Ni-B/B (0.1 g/dm^3) HT	6162	3403	66
Ni-B/B (1.5 g/dm^3)	6486	4529	138
Ni-B/B (1.5 g/dm^3) HT	8197	5223	131

CONCLUSIONS

The study investigated the influence of the dispersion phase content in the bath on the properties of produced Ni-B and Ni-B/B coatings as well as the effect of the heat treatment. Incorporation of boron particles into the Ni-B matrix affects the structure, morphology and mechanical properties of the composite coatings. The thickness of the coatings decreases as the content of particles in the bath increases. The microhardness of composite coatings is higher than Ni-B alloy coating, with the highest value of 1080 HK0.025 for Ni-B/B (1.0 g/dm^3) coating. Moreover, heat treatment increases the microhardness of all coatings. This is due to the presence of the Ni_3B phase in the coating structure, which was formed after heat treatment.

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*** Corresponding author: katarzyna.skroban@imp.lukasiewicz.gov.pl**