ELECTRON IRRADIATION EFFECTS ON h-BN AND h-BN-TiB2 COMPOSITES

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1. INTRODUCTION

Hexagonal Boron Nitride (h-BN) is an important ceramic material which has wide applications in industry because of its good properties such as high thermal and electrical conductivity, low coefficient of thermal expansion /1/. h-BN and its composites used in industry in some high temperature applications. In addition they also could be used for semiconductors and making improved to other materials because of h-BN's structure similarity with graphene /2, 3/. On the other hand for improving h-BN for applications, there are some methods which include irradiation of materials /2/ and using some additives /3/. With irradiation its possible to introduce defects in h-BN and edge structures /3, 4/.

There are several researches about irradiation BN and related materials/2-6/. It has been reported that the wear resistance and radiation resistance of h-BN and some related materials are improved by electron irradiation/3-5/. In addition it is shown that h-BN membranes are more resistant than graphene under electron beam radiation/4/. Also some defect probabilities such as single vacancies, double vacancies, complex vacancies and amorphizations were carried out for h-BN under irradiation by computer simulations/5/. In this study electron irradiation effects on h-BN and hexagonal boron nitride-titanium diboride (h-BN-TiB2) composites were investigated.

2. EXPERIMENTAL

In the experiments h-BN and boron nitride-titanium diboride materials were used. The materials were sintered at 1800 °C under Nitrogen atmosphere without pressure for 2 hours. During the production process titanium nitride (TiN) layer were occurred on surface of materials. Therefore TiN analysis's were also carried out beside h-BN and h-BN-TiB2. Boron nitride-titanium diboride materials were composited by 55% boron nitride and 45% titanium

diboride volume ratio.

Materials were irradiated by electrons which have 4 MeV energies at The National Practical Center on Materials Research of National Academy of Science of Belarus. Different electron irradiation doses up to $3.7x10^{16}$ cm^{-2} were applied to samples at room temperature.

XRD, SEM and EDX analyses were carried out for initial and irradiated samples at different doses. The phase composition of the samples was investigated by the X-ray diffraction analysis (XRD) in Bragg- Brentano geometry and copper radiation using a DRON 4-13 diffractometer. Surface morphology as well as samples element composition was analyzed by means of scanning electron microscopy using a LEO1455VP device equipped with an energy-dispersive X-ray Rontec detector. The structure features of boron nitride and titanium diboride were carried out. The parameters of crystalline lattices and volume of the cells were investigated for boron nitride and titanium diboride materials at each dose value.

3. RESULTS and DISCUSSION

SEM analyses of h-BN and h-BN-TiB2 composites were observed as initial and irradiated samples which were shown in Fig 1.The average particle size of h-BN is 700 nm diameter and 100 nm thickness (plate shaped) and 4 μm for TiB2. Also there are some nonhomogenous distribution on the surface. On the other hand mainly there is no change according to SEM and EDX analysis's.

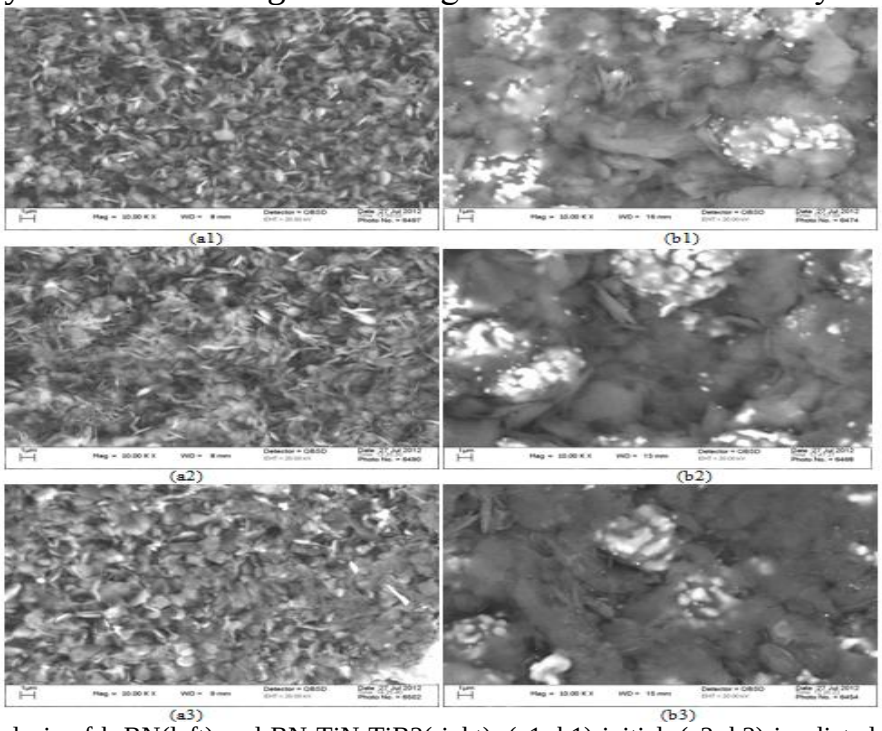
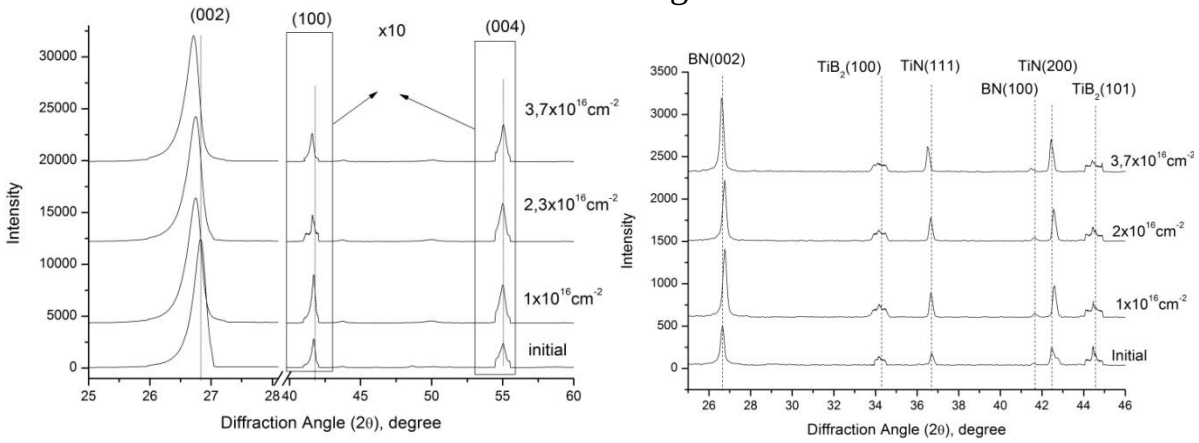


Fig 1. SEM analysis of h-BN(left) and BN-TiN-TiB2(right); (a1, b1) initial, (a2, b2) irradiated by $1x10^{16}$ cm^{-2} dose, (a3, b3) irradiated by $3,7x10^{16}$ cm^{-2} dose.

For initial (unirradiated) and irradiated samples of h-BN and h-BN-TiB2

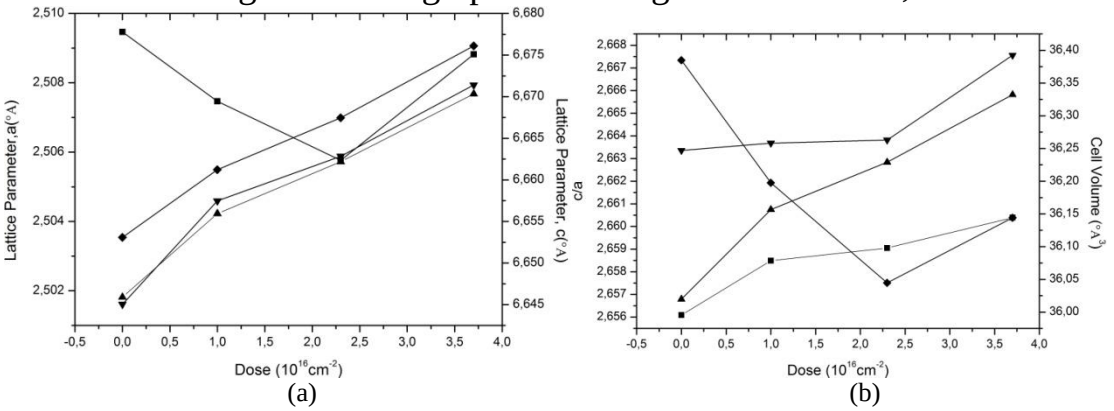
composites XRD results were investigated. h-BN results were shown on Fig 2a and h-BN-TiB2 results on Fig 2b. It could be seen that diffraction angle values for the materials are decreased with increasing dose.



(a) (b)

Fig 2. XRD analysis of h-BN and h-BN-TiB2 composites initial and electron irradiated samples.

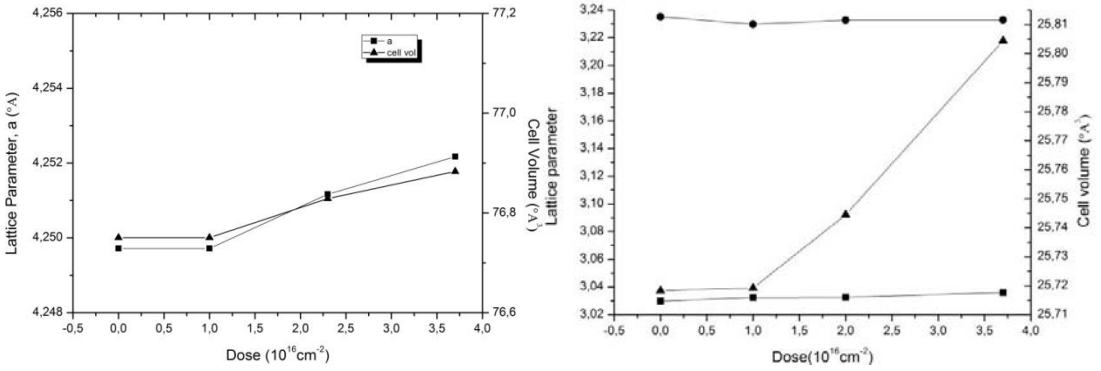
The lattice parameters and cell volumes of h-BN and h-BN-TiB2 composites which were given as graphs in Fig 3a and 3b, were calculated.



(a) (b)

Fig 3. (a) The Lattice Parameters of h-BN; (▼) is a of hBN, (▲) is a of (hBN-TiB2), (■) is c of hBN, (◆) is a of hBN (hBN-TiB2). **(b)** c/a and cell volume graph for h-BN against dose. (▼) is cell volume of hBN in h-BN-TiB2, (▲) is cell volume of h-BN, (◆) is c/a of h-BN in BN- TiB2, (■) is c/a of h-BN.

For h-BN in h-BN-TiB2 composites the lattice parameters (a, c) and cell volumes are increased with higher dose of electron irradiation where the c and c/a for h-BN in h-BN-TiB2 composites is decreased. For TiN and TiB2 for BN-TiB2 composites, the lattice parameters and cell volumes were calculated at each irradiation dose. The lattice parameter-dose and cell volume-dose graphs were drawn on Fig 4. It could be said that the lattice parameters of TiN and TiB2 were increased with rising dose same as cell volume. The error percentage of the values is range between 0,25-0,50 % related with the samples. The cell volume expansions are 0,87 % for h-BN, 0,4% for h-BN in hBN-TiB2 composite, 0,33% for TiB2 and 0,17% for TiN at $3,7x10^{16}cm^{-2}$ dose.



(a) (b)

Fig 4. The Lattice Parameters and cell volume of TiN (a) and TiB2 (b); In (a), (■) is lattice parameter a and (▲) is cell volume for TiN, in (b) (■) and (⬮) is lattice parameters a and c respectively,(▲) is cell volume for TiB2.

It is understood that the biggest cell volume expansion occurred in pure h-BN sample. On the other hand, adding TiB2 decreased the swelling percentage of h-BN at same dose irradiation where is nearly half of pure h-BN.

4. CONCLUSION

As a result pure h-BN and h-BN-TiB2 composites were irradiated by 4 MeV electrons at different doses. At first, cell volume values for irradiated samples are higher than initial samples. The biggest cell volume change is taken place for h-BN sample at biggest dose irradiated. Secondly, when the volume change is compared that h-BN and h-BN in h-BN-TiB2 composites, pure h-BN samples have bigger volume expansion than h-BN-TiB2 composites which is approximately twice times of h-BN-TiB2. Also TiB2 and TiN volume expansion values are less than h-BN. Finally, the doses which accumulated in the samples cause higher cell volume values for the samples. The accumulation evaluation of defects carried out for pure h-BN and h-BN-TiB2 samples.

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