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ИЗУЧЕНИЕ ПРОЦЕССА ФОРМИРОВАНИЯ ПОКРЫТИЙ БОРА И ОКСИДА МЕДИ

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STUDY OF THE PREPARATION CuO AND BORON FILMS

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В представленной статье рассматриваются покрытия бора и оксида меди, осажденные с помощью распыляющего ионного источника. Скорость осаждения покрытий варьировалась от 11 до 11.8 нм/мин. Морфология и состав исследовались с помощью атомно-силовой микроскопии и рентгеноструктурного анализа. Данные исследования показали, что борные покрытия имеют более однородную структуру по сравнению с покрытиями оксида меди.

***Ключевые слова**: атомно-силовая микроскопия, бор, распыляющий ионно-лучевой источник, процесс горячего изостатического прессования, рентгеноструктурный анализ.*

The use of ion beam source sputtering, CuO and B films were deposited successively. The deposition speeds are 11 nm/min and 11.8 nm/min, respectively. The purity and morphology of the as-prepared films were investigated by power X-ray diffraction and atomic force microscopy. Thus it is can be seen that the sizes of the films were more homogeneous in B than CuO.

***Keywords**: atomic force microscopy, boron, ion beam source sputtering, hot isostatic pressing, X-ray diffraction*

Introduction

It has been shown that CuO and boron are important industrial materials that can be widely used in physical and chemical applications such as electronics and semiconductors. In traditional applications, they are often made into micro or nano-scale powders to achieve metastable intermolecular composites (MICs). The MICs can release plentiful energy because of redox when activated.

In the past few years, the oxide and reducer have received considerable attention when they were made into reactive nano-multilayer films [1]. They are new energetic films that can be used widely such as igniter, micro jointing and so on. Besides, another important aspect: they can be integrated with silicon based microsystem. Some attempts have been made to achieve reactive nano-multilayer films. For example, K.J. Blobaum [2] reported CuO/Al films were used in micro jointing. Kaili Zhang [3] prepared CuO/Al films by micromachining.

However, it is well known that aluminum will form oxidation easily in atmosphere because of its activity. The reactivity of the films will be reduced when kept for a long time. boron is a very steady element in the atmosphere and can react with CuO quickly. The energy released from CuO/B is 738.1cal/g [4], which is almost the same as CuO/Al. So we manage to achieve CuO/B reactive nano-multilayer films and investigate its characteristics of reaction. In this paper, we want to describe the way of getting CuO and boron films using Ion Beam Source Sputtering so as to make preparations for farther research.

1 Experimental procedure

The HIP (hot isostatic pressing) provides a method for producing targets from diverse powdered materials, including metals and ceramics. In this paper, we describe the way of getting CuO and boron targets using this method. During the manufacturing process, CuO or boron powders were placed into a graphite container. The container was subjected to an elevated temperature and very high vacuum to remove air and moisture from the powders. The container was then sealed and pressed. The application of high nitrogen pressures and elevated temperatures results in the removal of internal voids and creates a strong metallurgical bond throughout the target. The target parameters of processing and dimension are shown in Table1.

Table1 – Parameter of “HIP”

Target	CuO	boron
Pressure/Mpa	30	30
Tem/ºC	800	1350
Shape	cylinder	cylinder
Diameter/mm	78	78
Height/mm	5	5
Purity	>99.9%	>99.9%

IBSS (ion beam source sputtering) is a physical vapor deposition method of depositing thin films by sputtering. The sputtered ions can fly from the target in straight lines and impact energetically on the substrates. Alternatively, at higher gas pressures, the ions collide with the gas atoms that act as a moderator and move diffusively, reaching the substrates or vacuum chamber wall and condensing after undergoing a random walk. The entire range from high-energy ballistic impact to low-energy thermalized motion is accessible by changing the background gas pressure. So the pressure of vacuum chamber is very important for depositing films. The elementary diagram of the "IBSS" is shown in Figure 1, and the working parameter is shown in Table 2.

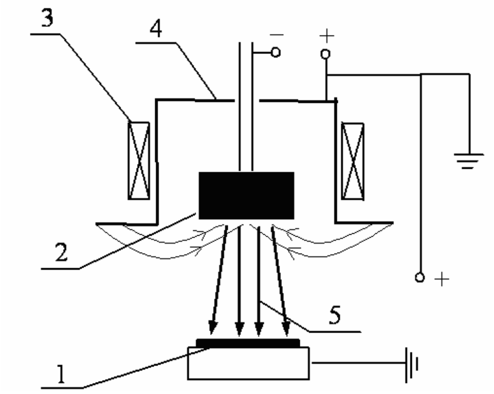

Figure 1 – Patter of the "IBSS"
(1 – substrate, 2 – target, 3 – magnetic loop, 4 – electrode, 5 – ion beam)

Table2 – Parameter of "IBSS"

Film	CuO	boron
Argon Pressure/Pa	10-2	10-2
Voltage/V	3000	5000
Current/mA	107	150
Power/W	316	740
Speed/nm·min-1	11	11.8

2 Results and discussion

Because boron target was made of pure boron powders, we can conclude that B films are pure. Since CuO target is oxide, we can not identify if the composition of CuO films has been changed or not after deposition. So the purity and the composition of the CuO films were further investigated by X-ray diffraction (XRD). Figure 2 shows the XRD pattern of CuO films. It was compared with the data of the PDF card [45-0937] and all peaks can be readily assigned to those of crystalline CuO, indicating the formation of single-phase CuO with a monoclinic structure. This result clearly indicates that the obtained CuO films are really crystalline.

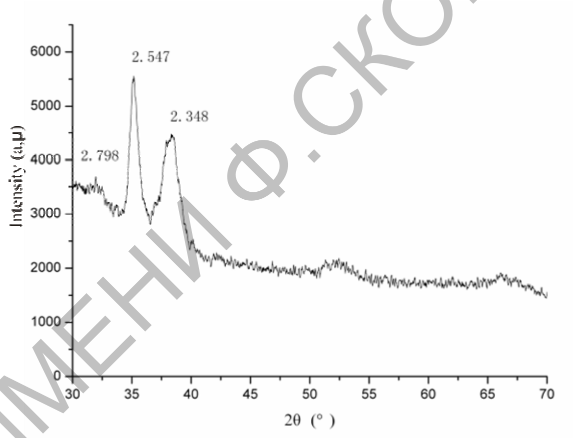

Figure 2 – XRD Patter of CuO films

We can find out the vivid and plentiful images of the films from Atomic Force Microscopy (AFM). Figure 3 brought out the images of the topography and phase diagram of the CuO films and the sizes of the granules on its surface were about from 100 nm to 500 nm.

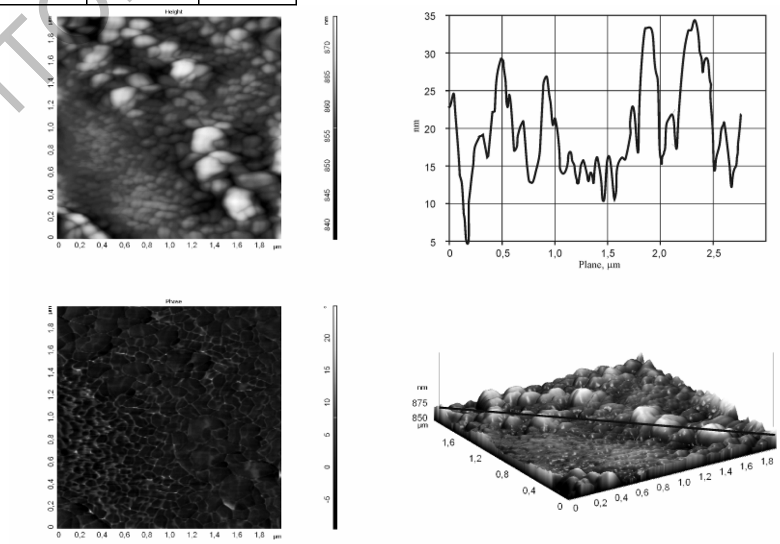

Figure 3 – AFM image of the surface of the CuO films with thickness 330 nm

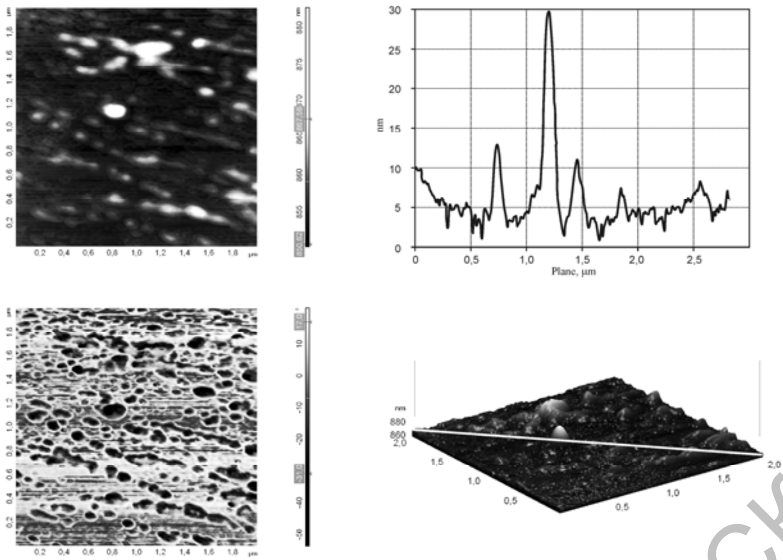

Figure 4 – AFM image of the surface of the B films with thickness 354 nm

More detailed and clear examination revealed that the big granules were congregated by the small particles (about 30 nm). It means that the big granules were not the unique structure. For boron films (Figure 4), the biggest particle was about 30 nm. Thus it is can be seen that the sizes of the films were more homogeneous in boron than CuO. From these results, we can conclude that CuO films should be deposited first, boron films should be deposited on the surface of CuO films in order to cover the granules of CuO films, thus we will achieve CuO/B reactive nano-multilayer films with good integration.

Conclusions

The CuO films and boron films were deposited via Ion Beam Source Sputtering successively. The composition, morphology and structure of the thin films were investigated by XRD and AFM. The results show that we can get pure films with good integration by Ion Beam Sputtering. Therefore, all this work has been prepared for investigating the characteristics of CuO/B reactive nano-multilayer films.

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