MORPHOLOGY INFLUENCE ON WATER WETTABILITY OF MO BACK CONTACT OF SOLAR CELLS

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Investigation of influence of Mo deposition on glass substrates by SIAD on its surface topography and wettability was conducted. We observe some steps in the process of film growth. Contact angle measurements showed that deposition of the Mo films on glass makes the surface less hydrophilic. It was indicated that with an increase of the irradiation dose, the roughness and contact angle increases rapidly at first and then decreases.

1. Introduction

Several metals have been investigated for using as back contact of $CuInSe_2$ and $CuIn_{1-x}Ga_xSe_2$ solar cells. The choice of Mo as the material for back contact layer of solar cells is based on the requirements imposed by the application and the different processing steps. Mo as back contact has desired stability at the processing temperature, resistance to alloying with absorber layer elements such as Cu and In, and its low contact resistance The solar cell is dependent on a structural layer to support the solar cell mechanically. Mo back contact is considered as crystal seed grains for the growth of CIGS absorber [1]. Thus, we shall focus attention on deposition molybdenum layer on glass substrate in order to investigate the structural properties of Mo back contact on glass.

Among the various methods, vacuum evaporation is relatively successful in many cases when improved adhesion is important. The self-ion-assisted deposition method provides ion-beam-mixing of the substrate atoms and atoms of a thin film without introducing an admixture of noble gases. SIAD was known to affect the crystalline structure, packing density, adhesion, surface smoothness of the film and could enhance the quality of thin film for functional devices [2].

In this report, for the first time the Mo thin films were prepared on glass substrates by SIAD at different irradiation doses. The surface morphology and the surface hydrophobicity of the obtained films were characterized.

2. Experimental

Film deposition was carried out in a vacuum chamber with a base pressure in the range of 10^{-2} Pa. SIAD experiments were performed using a resonance vacuum arc ion source. Substrate plates were floated to a negative potential with respect to the source of 10 keV to accelerate the ion species. The beam current density was kept of 5.1 μA/cm^2. The dose of ions was 1.2·10^{16}, 3.2·10^{16}, 5.2·10^{16}, 8.1·10^{16}, 1.1·10^{17} cm^{-2}.

Atomic force microscopy study of samples was performed with an micro-scope “NT-206” using AFM cantilevers CSC21. The wetting behavior is characterized by the value of the contact angle (Θ_0). Contact angle measurement was based on the sessile-drop method. The original setup for measuring the value of the contact angle by this method is demonstrated in [3]. The wetting agent was doubly distilled water. The total error of our measurements is $\Delta\Theta = 0.5°$.

3. Results and discussion

3.1. Surface morphology

The AFM was utilized to examine the topography of initial glass and Mo films on glass (Fig. 1). These pictures indicate how the surface changes with the increase of the irradiation dose. The parameters are listed in the Table.

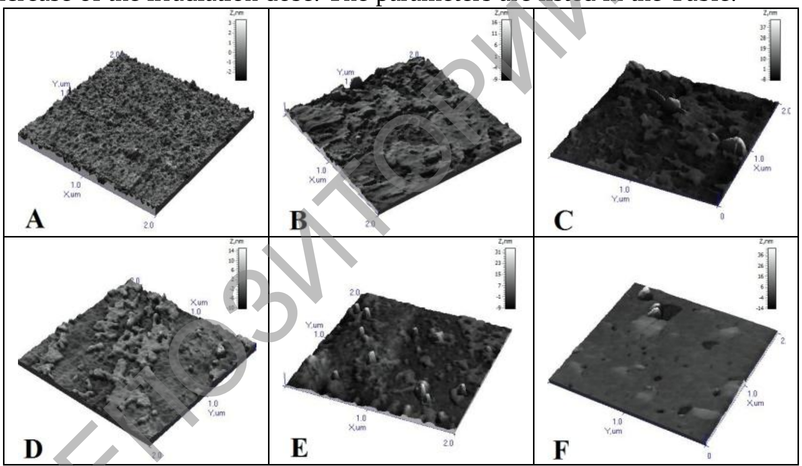

Figure 1. AFM-images of initial glass (A) and Mo coating on glass obtained at 1.2·10^{16} (B), 3.2·10^{16} (C), 5.2·10^{16} (D), 8.1·10^{16} (E), 1.1·10^{17} (F) cm^{-2}

Table. The topography and wettability parameters of the investigated samples

Irradiation dose, ·10^{16} cm^{-2}		1.2	3.2	5.2	8.1	11
Nominal area, μm^2	99.2	98.4	97.5	98.4	98.4	97.5
Full area, μm^2	99.3	98.5	97.7	98.5	98.5	97.8
R_a, nm	2.2	1.8	2.0	2.7	2.3	2.3
% of coating formation		56.9	33.6	34.5	48.1	96.5
Δh, nm		7.2	6.0	4.6	3.0	3.0
Contact angle Θ, °	25.1	62.8	67.4	69.7	60.8	56.7

On Fig. 1 we observe the initial stages of formation and growth of the films. We can find the degree of homogeneity coating and its thickness by building histograms of heights and cross sections of 2D AFM images.

An interesting feature was observed for the samples obtained at irradiation doses more than $5.2 \cdot 10^{16}$ cm^{-2}. There are rare columns 30 nm high and 0.1μm in diameter on the surface. These columns have reduced as compared to coating, resistance to mechanical stress. The experimental conditions allow to avoid deposition of the large clusters on substrate. So we assume that it is glass columns, formed by redeposition of sputtered elements of the substrate.

Assessing the % of coating formation, we see a decline from 56.9% to 33.6% at the initial stage of the coating formation. This is possible only when the observed multi-level surface is not a surface of the coating and the substrate, but the surface of the coating deposited unevenly on different parts of the surface at the initial stage of the coating formation. This is evidenced, in particular, reducing the difference of heights (Δh, Table) from 7.2 nm to 3 nm with an increasing of the irradiation dose and therefore the deposition time.

The roughness of initial glass is 2.2 nm. The AFM studies revealed presence of irregularly distributed valleys and hills on the surface of glass (Fig. 1 A). Dependence of R_a vs. the irradiation dose (Fig. 2 A) is similar to the previously obtained results [4] of the influence of Xe^+ ions irradiation of graphite on its topography and wettability.

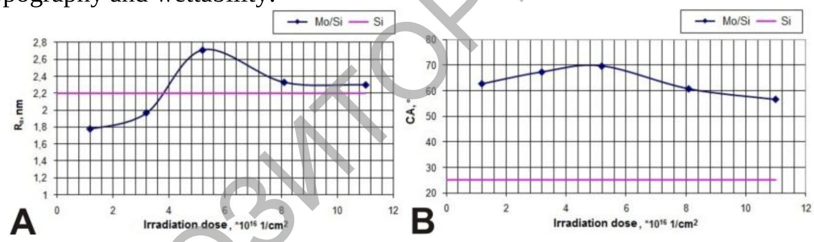

Figure 2. Evolution of R_a (A) and the contact angle (B) vs. the irradiation dose.

After the start of deposition of coating the character of the surface topography changes drastically. In contrast to the initial sample is significantly reduced number of small irregularities, the surface of the substrate becomes smoother (Fig. 1, Fig. 2 A). The roughness increases with the increase of the irradiation dose to 2.7 nm due to the difference of levels of covering and the multitude of islands of covering nucleation. With further increasing of the deposition time the area of covering increases, gradually filling the entire surface, which reduces the roughness to 2.3 nm. These results indicate the possibility of managing the roughness of the film surface by changing the dose during irradiation.

According to the qualitative description of evolution thin films synthesized on amorphous and polycrystalline substrates [5] we observe the following steps in the process of film growth: island growth, impingement and coalescence of islands, development of a continuous structure.

3.2. Wettability test

The wettability test results show fundamental difference between the contact angle of initial glass (25.1°) and the contact angle of experimentally modified surfaces (56.7° – 69.7°). We observe increasing in 2.45-2.77 times in the contact angle of water when the Mo thin film is deposited on glass. So, Mo coatings deposition on glass makes the surface less hydrophilic.

The dependence of the value CA from a dose of ion irradiation (Table, Fig. 2 B), as traced by the change in the form of water drops on the surface of the samples, is similar to the dependence of the average roughness from a dose (Fig. 2 A). We can conclude that the change in water wettability surface modified samples is mainly due to changes in surface roughness.

Obviously, all three factors affect on the wettability of the surface in that case: chemical composition of the material (fact deposition of Mo-films), local inhomogeneity (% of coating formation) and surface morphology (roughness).

These results indicate the possibility of managing the water wettability of the Mo coating on glass substrates by changing the dose during irradiation.

4. Conclusions

It was indicated that with an increase of the irradiation dose, the roughness increases rapidly at first and then decreases. The threshold value of irradiation dose excess of which leads to decrease in roughness of a surface is $5.2 \cdot 10^{16}$ cm^{-2}. It has been also qualitatively estimated that coating harder than a substrate.

Contact angle measurements showed that deposition of the Mo thin films on glass makes the surface less hydrophilic. We observe increasing in 2.45-2.77 times in the contact angle of water when the Mo thin film is deposited on glass.

The dependence of the value CA from a dose is similar to the dependence of the average roughness from a dose. We have observed that deposition of Mo thin film on glass with different doses can be used for receiving surface with desirable topography and water wettability.

References

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