

Surface morphology and optical properties of magnetron – sputtered ultrathin Al films

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ABSTRACT

Ultrathin Al films with different thicknesses were deposited on glass substrates by DC magnetron sputtering. The effects of film thickness on morphology and optical properties of the films were investigated in detail. When film thickness increases from 7.0 to 84.0 nm, the average grain size and surface roughness enlarges from 27.6 to 94.2 nm and from 0.25 to 1.87 nm, respectively. Below critical thickness of 28.0 nm, which is the thickness that Al films form continuous film, the optical properties vary significantly with thickness increasing and then tend to be stable. In the absorptance spectra, all films exhibit distinct broad peaks which can be attributed to the absorption due to the interband transition. The possible reasons for the shift in the peak position are due to the quantum size effects and internal stress in the ultrathin Al films.

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1. Introduction

Metal thin films, a very important class of optoelectronic material, have been extensively studied and applied due to their unique optical, electrical and mechanical properties which are much different from corresponding bulk materials [1]. Compared with other metal thin films, Al thin films exhibit good electrical conductivity and thermal conductivity, high reflective performance for infrared, ultraviolet, electromagnetic wave, and heat radiation [2]. At the same time, Al thin films also have a strong sound-absorbing and nuclear radiation-resistant nature [3]. In addition, lower cost than other metal thin films may be another attractive advantage. So, Al thin films have broad applications in modern technology such as thin film transistors [4], flat panel displays [5], sensors [6], superconducting tunnel junctions [7], multilayer transparent conductive coatings [8], anti-reflection coatings [9], and so on. Ultrathin Al films, thickness $t < 100$ nm, are of technological importance for microelectronic and optoelectronic devices [10,11]. Consequently, the research on the films is of very important practical significance.

Most of the previous investigations on ultrathin Al films were focused on their electrical and mechanical properties [12,13]. Few reports have been made on the optical properties, especially

the correlation between optical properties and microstructure of the films. Generally, there are many techniques for preparing Al thin films, such as molecular beam epitaxy (MBE) [14], chemical vapor deposition (CVD) [15], ion beam assisted deposition (IBAD) [16], RF and DC magnetron sputtering (MS) [17], atomic layer

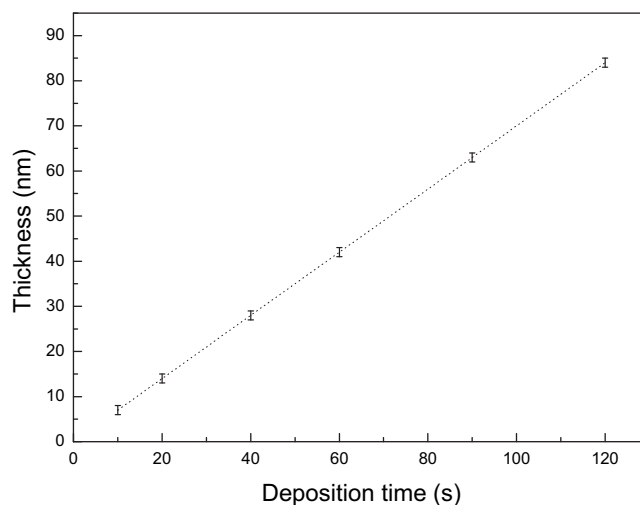


Fig. 1. Dependence of the film thickness on the deposition time for ultrathin Al films.

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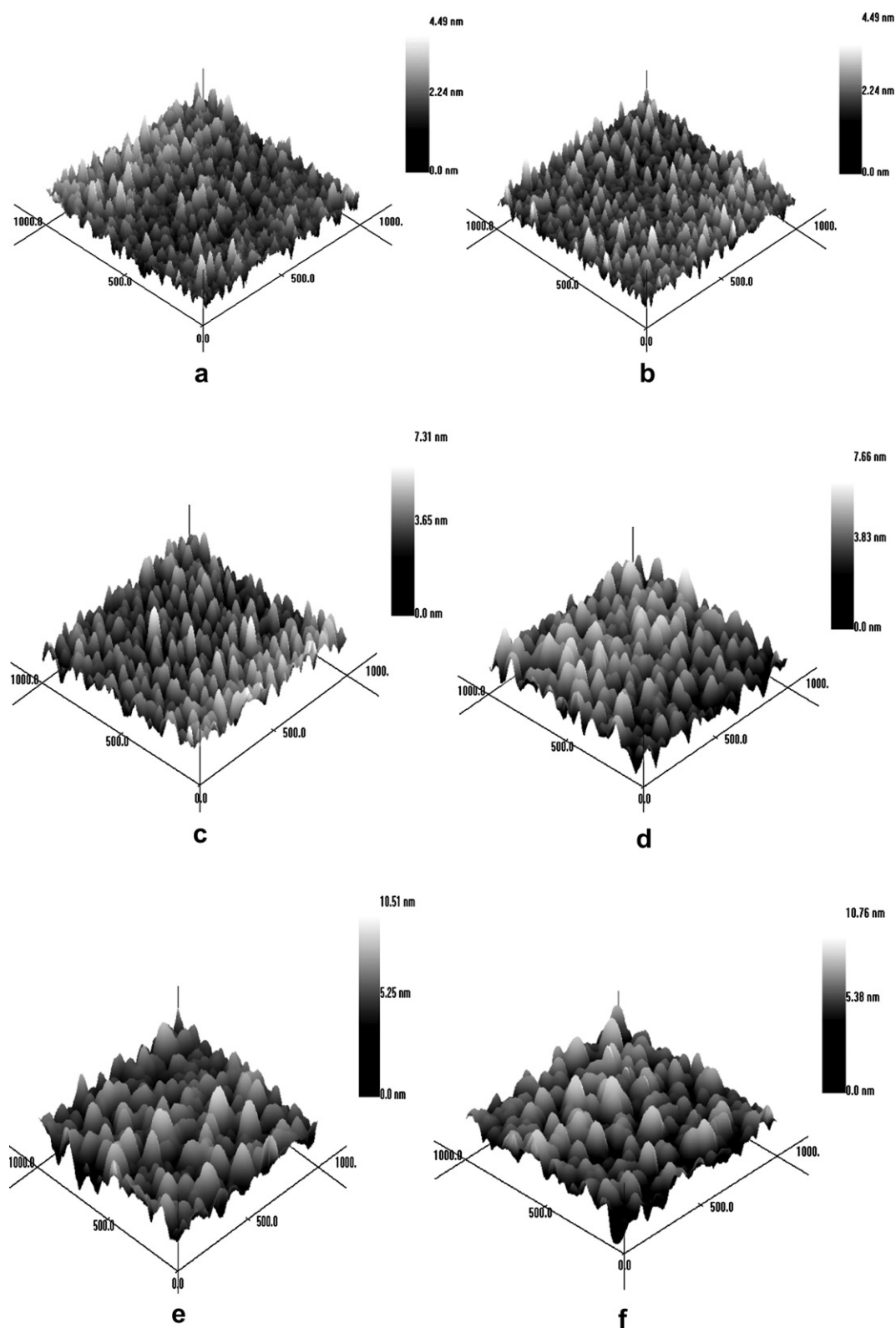


Fig. 2. 3D AFM images of ultrathin Al films with different thicknesses on glass substrates: (a) 7.0 nm, (b) 14.0 nm, (c) 28.0 nm, (d) 42.0 nm, (e) 63.0 nm, (f) 84.0 nm.

deposition (ALD) [18], electron beam evaporation [19]. Amongst these methods, DC magnetron sputtering, which has been widely employed to deposit metal films for the practical applications, is versatile owing to high growth rate, superior quality of deposited

films, and the simplicity of the deposition system required [20]. The aim of the present work is to study the influence of film thickness on the morphology and optical properties of ultrathin Al films.

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