Changes of the texture of Ti films caused by ion-plasma treatment

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Introduction

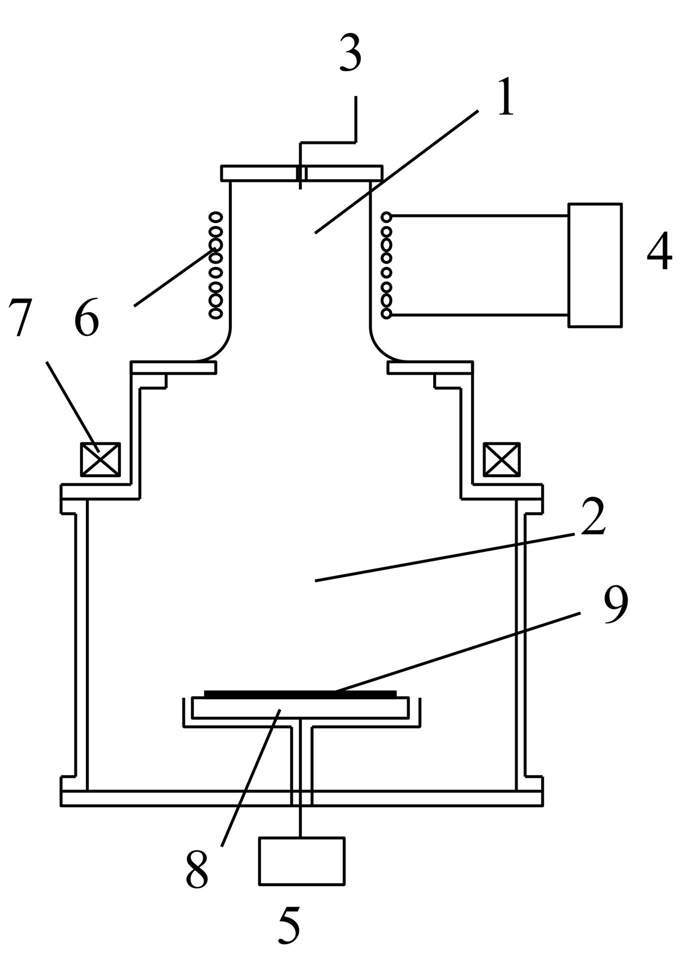
Thin textured Ti films are widely used as adhesive underlayer for Al, AlN, TiN, Pt and ferromagnetic films. α-Ti films with fiber (001) texture are used for this purpose. The strengthening of underlayer texture leads to the strengthening of the texture of films deposited on it. The ion bombardment of film during deposition is used frequently to obtain the films with controllable texture parameters. The influence of post-deposition ion bombardment of Ti films on their texture has not yet been investigated. However such a procedure is widely used for the surface modification of adhesive underlayers Ti and for stress modification in metallic films. The purpose of present work is the investigation of the low-energy post-deposition Ar ion bombardment on thin film Ti texture.

Specimen preparation

Ti films with thickness h=10-40 nm were deposited on oxidized Si(100) by RF-magnetron sputtering at room temperature and Ar pressure 2 μbar.

Ti films were exposed to the series of four ion-plasma treatments (IPTs) in Ar plasma after deposition. The IPTs were carried out at Ar pressure 0.08 Pa, film temperature didn't exceed 320 K and ion current density was 7.4 mA/cm^2. The duration of every IPT was 30 min and substrate bias was 20, 25 and 30 V.

Schematic of the reactor



1 – discharge chamber. 2 – reaction chamber. 3 – input gas. 4, 5 – RF-generators. 6 – induction coil. 7 – DC current coil. 8 – water-cooled specimen holder. 9 – specimen.

EDS analysis

The film thickness before and after every series was measured using EDS spectrometer INCAx-act (Oxford Instruments) attached to SEM Supra-40 (Carl Zeiss). The intensity of $Ti_{K\alpha}$ line was measured for 10-40 nm as-deposited films using INCAx-act system (Oxford Instruments) attached to the SEM Supra-40 (Carl Zeiss). The thickness of these films was measured directly in SEM, thus, calibration curve thickness-intensity was plotted. The intensity of $Ti_{K\alpha}$ line was measured for films after every IPT and the film thickness was calculated using calibration curve.

It was found that films were thinned by 4-5 nm during 30 V series and by 1-2 nm during 25 V series. The change of film thickness was not observed during 20 V series.

AES analysis

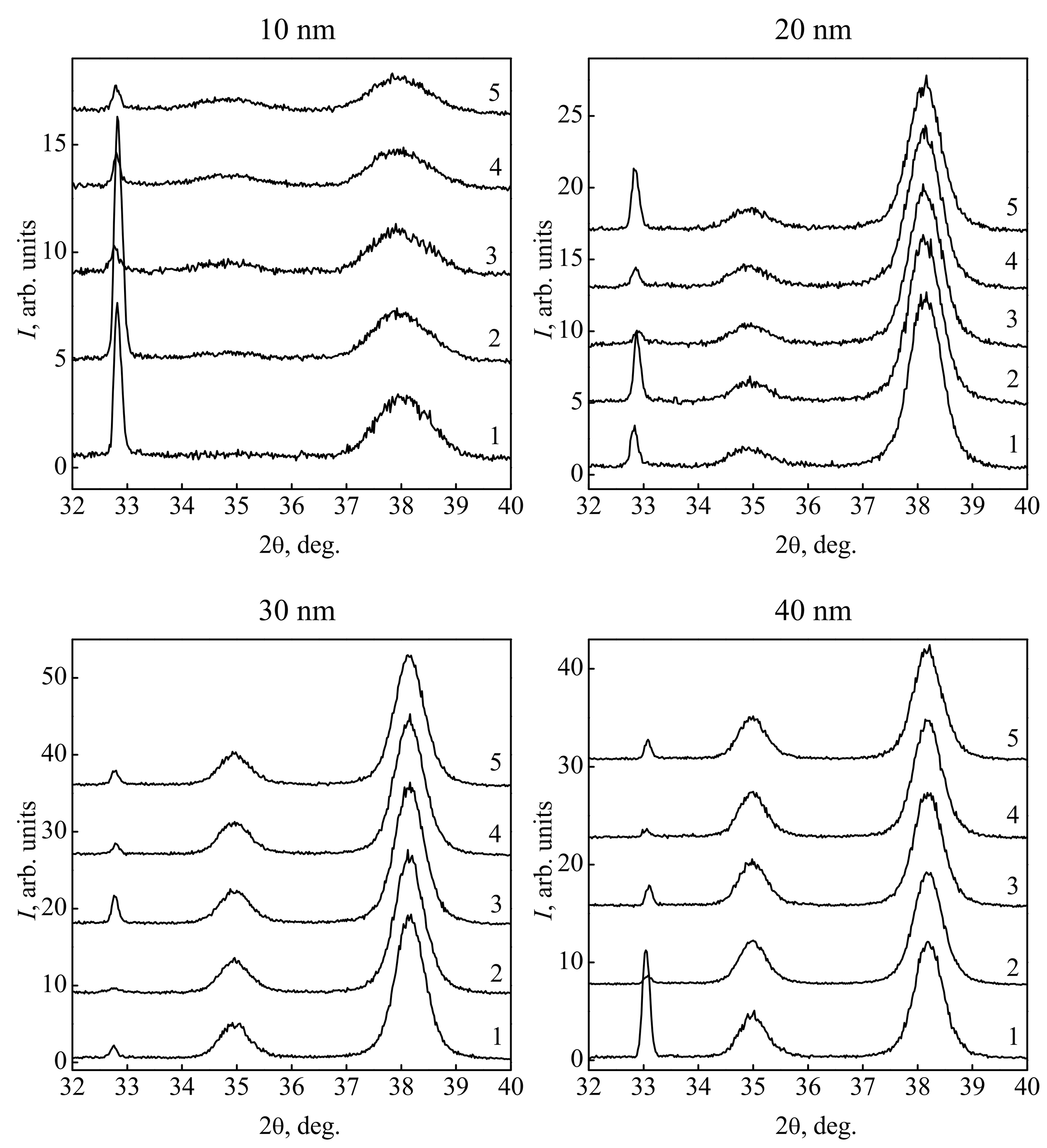
The chemical composition of films before and after every IPT was analyzed using EDS and AES technique. AES measurements were carried out using PHI-660 spectrometer (Perkin-Elmer). The chemical composition in at.% for 10 and 20 nm films are presented in table.

Chemical composition of 10 and 20 nm Ti films before and after 30 V series.

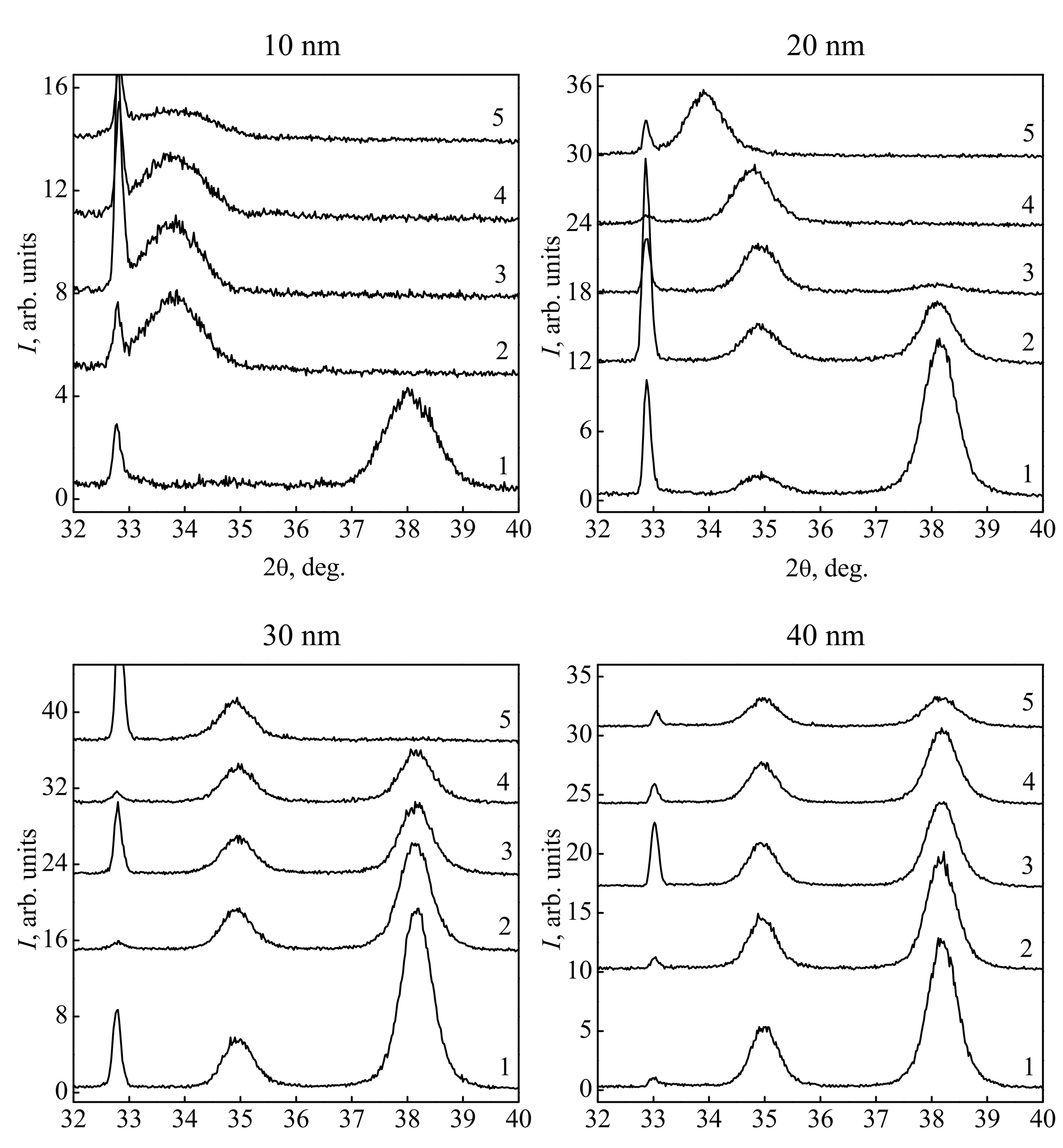
	n, at%			
	C	O	Si	Ti
10 nm As-dep.	35	47	-	18
20 nm As-dep.	39	45	-	16
10 nm 120 min	50	29	9	12
20 nm 120 min	50	28	9	13

X-ray diffraction

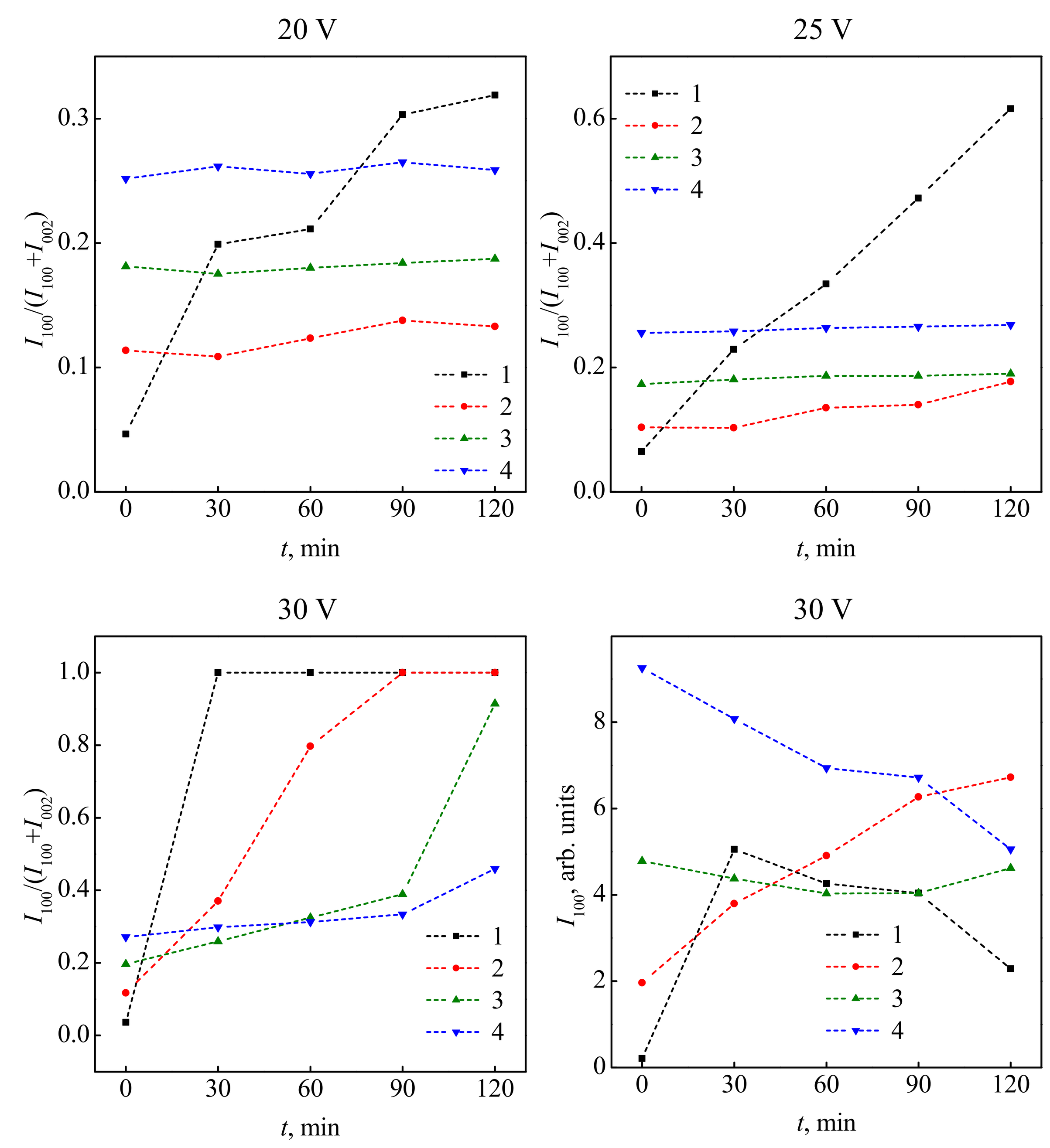
As-deposited films have mixed texture (100) + (001) and the (100) oriented fraction increases with film thickness. IPTs lead to the weakening of diffraction peak Ti (002) and the peak Ti (100) increases. The relative intensity of the peak (100) $I_{100}/(I_{100}+I_{002})$ increases faster for thinner films and for higher bias.



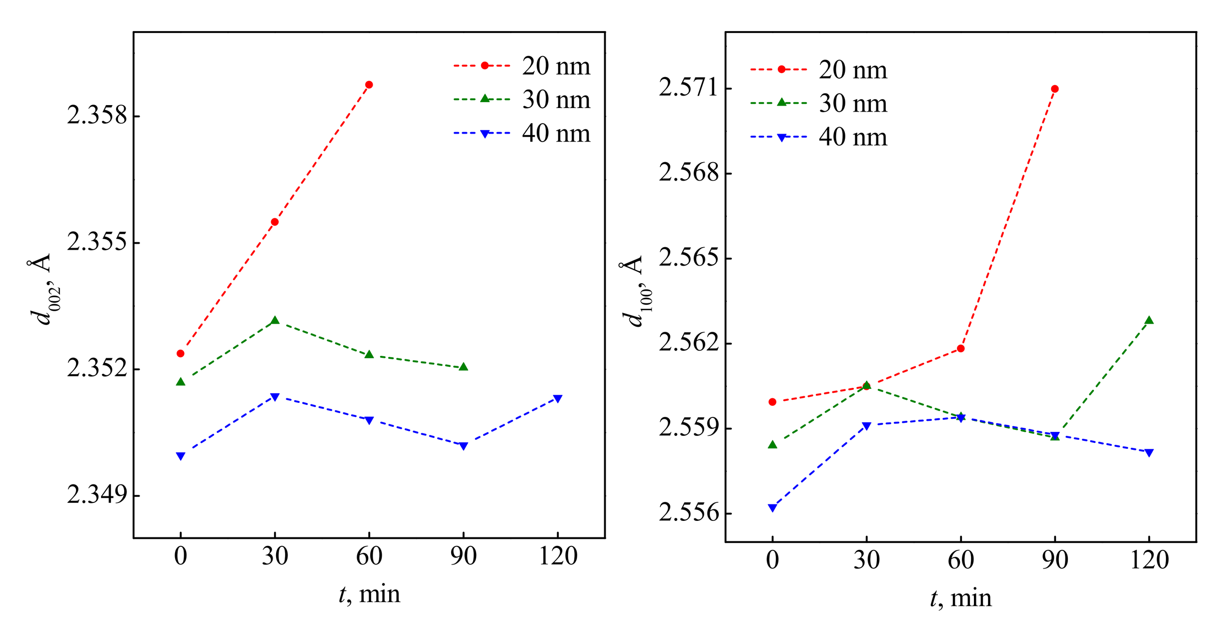
Diffractograms of 10, 20, 30, 40 nm Ti films, as-deposited (1) and exposed to one (2), two (3), three (4) and four (5) ion-plasma treatments at 20 V.



Diffractograms of 10, 20, 30, 40 nm Ti films, as-deposited (1) and exposed to one (2), two (3), three (4) and four (5) ion-plasma treatments at 30 V.



Relative intensity of the Ti peak (100) $I_{100}/(I_{100}+I_{002})$ and absolute intensity I_{100} and vs treatment time.



Interplanar distances for diffraction peaks Ti (002) and Ti (100) vs treatment time for 30 V series.

Discussion

It was found that the relative intensity of the titanium peak (100) $I_{100}/(I_{100}+I_{002})$ increases faster with the treatment time for thinner films and for higher bias.

It is known that the treatments carried out in similar conditions lead to the increase of compressive stress in thin chromium films due to surface and gain boundary diffusion. It's known that (100) texture in titanium films is stress-induced, thus the (100) texture formation can be explained by the increase of compressive stress caused by ion bombardment. Faster grain reorientation for thinner films and for higher bias can be explained by the smaller grain size and by higher atomic mobility respectively.

It was found that interplanar distances for peaks (100) and (002) measured along the film normal increase for thinner films and for bias 30 V. The increase of interplanar distances indicates the increase of compressive stress and thus, confirms the explanation given above.