

Effect of sputtering power on optical Properties of RF sputtering deposited Ti6Al4V Thin Films

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Abstract

Ti6Al4V thin film was prepared on glass substrate by RF sputtering method. The effect of RF power on the optical properties of the thin films has been investigated using UV-visible Spectrophotometer. It's found that the absorbance and the extinction coefficient (k) for deposited thin films increase with increasing applied power, while another parameters such as dielectric constant and refractive index decrease with increasing RF power.

Key words

Thin Films, RF Sputtering, Optical Properties, Ti6Al4V.

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تأثير القدرة المجهزة لمنظومة الترددات الراديوية على الخصائص البصرية لأغشية Ti6Al4V الرقيقة

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الخلاصة

تم تحضير اغشية رقيقة من سبيكة (Ti6Al4V) على ارضيات زجاجية باستخدام تقنية الترددات الراديوية. تم دراسة تأثير القدرة المجهزة على الخصائص البصرية للأغشية الرقيقة باستخدام تقنية امتصاص الأشعة المرئية فوق البنفسجية. وجد ان معامل الامتصاص والخمود يزدادان بزيادة الفولتية المجهزة. بينما باقي المعاملات مثل ثابت العزل ومعامل الانكسار تقل بزيادة الفولتية المسلطة.

Introduction

Thin metal films has attracted large scientific and practical interest since their specific properties enable various applications as transparent conductive coatings for UV spectrum [1, 2], transparent electrodes for “smart windows” and solar cells [3]. Titanium and its alloy arid due to its biocompatibility, mechanical, chemical stability and Osseo integration widely used for indications such as central implants, or the poetics and otology[4].

Biometals, alloys had wide application in medical field, titanium and it is alloy and stainless steel was the famous biometal an alloys that use in dental and orthopedic application, because they had an excellent mechanical properties and good corrosion resistance [5-7].

Optical experiments provide a good way of examining the properties of materials thin films. In these layers, metal thin films may represent continuum or un-continuous (island)

structures. Thin films are partially transparent and conductive at the same time. Evidently, the island shape of the metal film increases their transmittance and decreases their conductivity [1]. Transmittance (T) is given by ratio of the intensity of the transmitting rays (I_T) through the film to the intensity of the incident rays (I_o) on it as follows [8], while the absorbance is defined as the ratio between absorbed light intensity (I_A) by material and the incident intensity of light (I_o) [9]. And the reflectance can be obtained from absorption and transmission spectrum in accordance to the law of conservation of energy by the relation [10].

$$R+T+A=I \quad (1)$$

The absorption coefficient (α) of semiconductor determined using the formula [11].

$$\alpha = (2.303 \times A)/t \quad (2)$$

In order to evaluate the extinction coefficient K [11], is given by following equation:

$$K = \alpha\lambda/4\pi \quad (3)$$

The refractive index can be defined as a ratio between the speed of light in a vacuum (c), and the speed of light in the medium, the value of refractive index (n) are calculated by using equation depending on the reflectance

and excitation coefficient (K_o) as in the following equation [11]:

$$R = \frac{(n+1)^2 + K_o^2}{(n+1)^2 + K_o^2} \quad (4)$$

Dielectric constant is defined as the response of the material toward the incident electromagnetic field. The real (ϵ_r) and imaginary part (ϵ_i) of optical dielectric constant can be calculated using the following equations [11].

$$\epsilon_r = n^2 - k^2 \quad (5)$$

$$\epsilon_i = 2nk \quad (6)$$

Experimental setup

In our study (Ti6Al4V) thin films prepared by using RF Sputtering (US-made, CRC 600 magnetron sputtering system) as shows Fig.1. Thin films were prepared on glass substrate in different power. The chamber was evacuated under low pressure (5×10^{-3}) mbar. The glass slides were sequentially cleaned in an ultrasonic bath with acetone and ethanol. Finally they were rinsed with distilled water and dried. The optical properties measurements for (Ti6Al4V) thin films obtained by using the UV-Visible recording Spectrometer (UV-2601 PC Shimadzu software 1700, 1650), made in Japan. The thickness of the films has been calculated using Device the FT-650 Film Thickness (FT) Probe System.

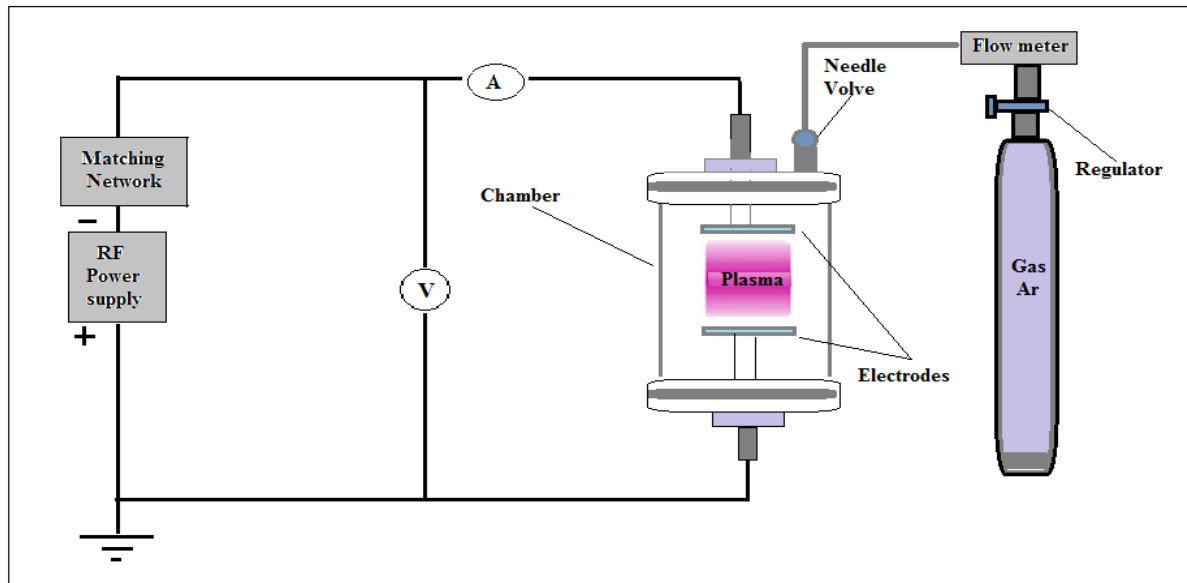


Fig.1: The CRC 600 magnetron sputtering system.

Results and discussion

The optical properties of the (Ti6Al4V) thin films deposited by (RF) magnetron sputtering were analyzed by UV-visible spectroscopy, in the wavelength range of (400-1100) nm as show in Fig. 2. The transmission spectra of (Ti6Al4V) thin film at different RF power (50, 75, 100, 125 and 150) Watt decrease with increase RF power as result of increasing films

thicknesses (244.89, 435.26, 598.98, 866.23 and 910.46) nm respectively. The transmittance pattern of all deposited thin films on glass is increases with the increase of wavelength (λ). The decrease in the transmittance spectra was caused by the increase in the loss of light scattering as the grain size increased [12].

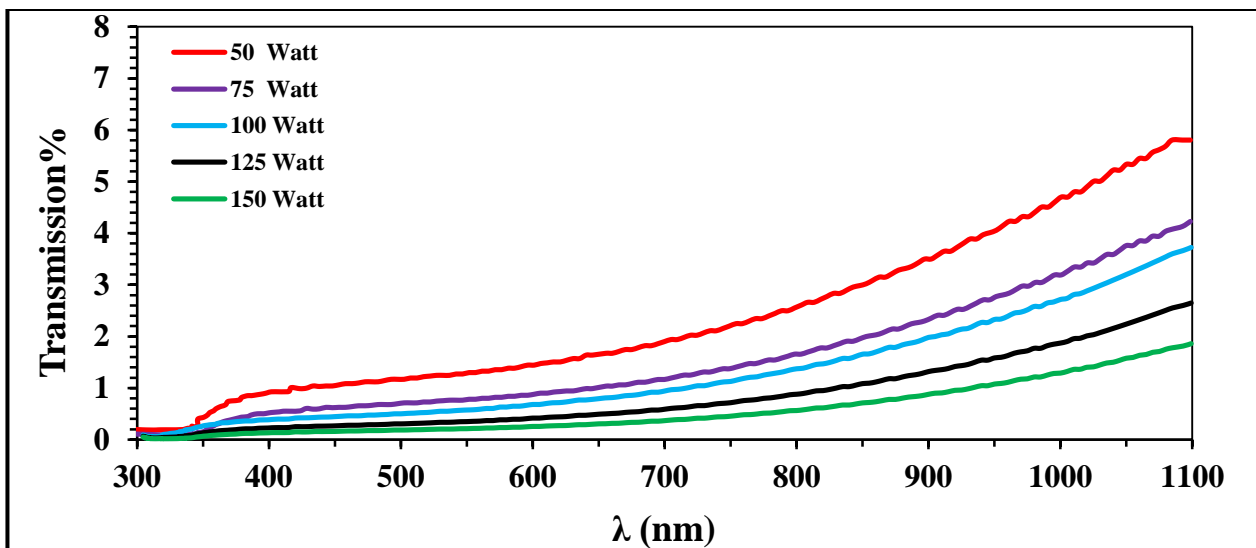


Fig.2: Transmittance as a function of wavelength for (Ti6Al4V) thin film at different working RF powers.

Absorbance spectra of (Ti6Al4V) thin films at different RF power were shown in Fig. 3. The increases in absorbance due to decrease in transmission associated with change in thickness. A careful look to this figure

showed that the optical absorption in the UV region is high. The Absorption pattern of all deposited thin films on glass was decreases with increasing wavelength.

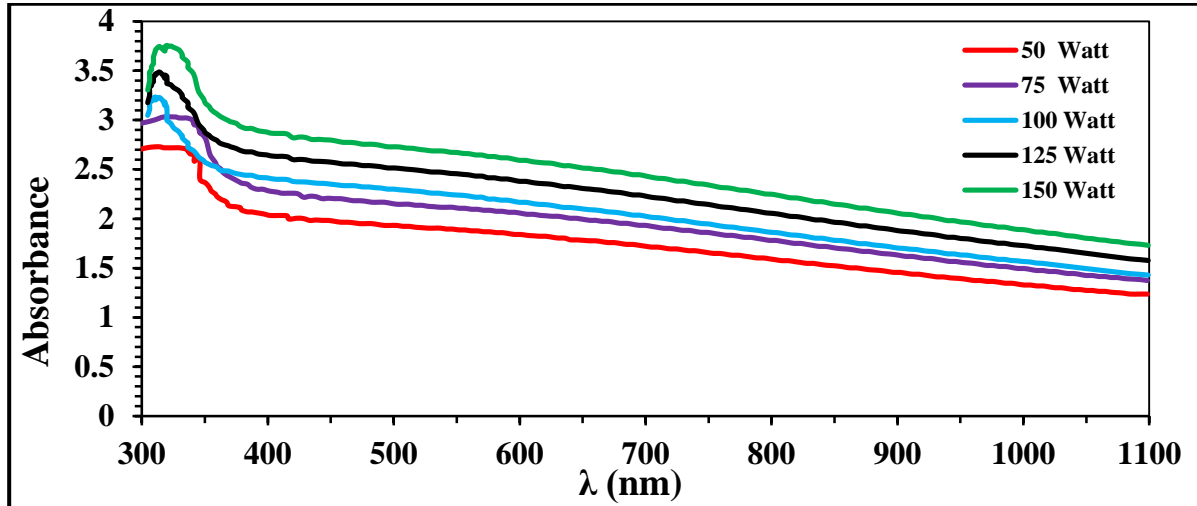


Fig. 3: Absorbance as a function of wavelength for (Ti6Al4V) thin film at different working RF powers.

Fig. 4 displays the absorption coefficient as a function of wavelength for Ti6Al4V thin films deposited at different RF powers. The absorption

coefficient increase with increase with RF power. Also, absorption coefficient deposited thin films on glass decreases with increasing wavelength.

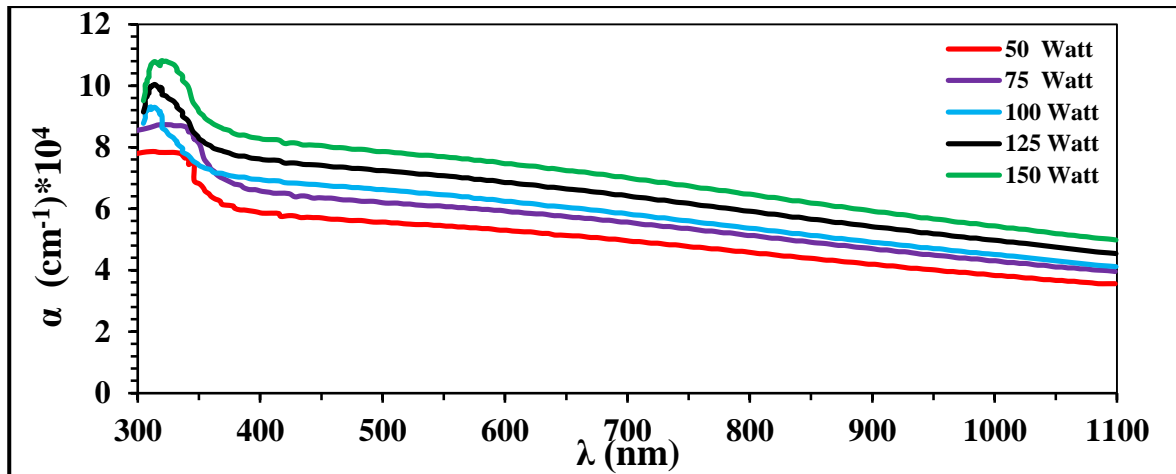


Fig. 4: Absorption coefficient as a function of wavelength for (Ti6Al4V) thin film at different working RF power.

Fig. 5 illustrates the variation of extinction coefficient with wavelength in the range of (400-1100) nm for (Ti6Al4V) films deposited on glass substrate for at different RF powers. The extinction coefficient depends

mainly on absorption coefficient for this reason we noticed that the increases of extinction coefficient with increasing wavelength because the increment in absorption coefficient[13].

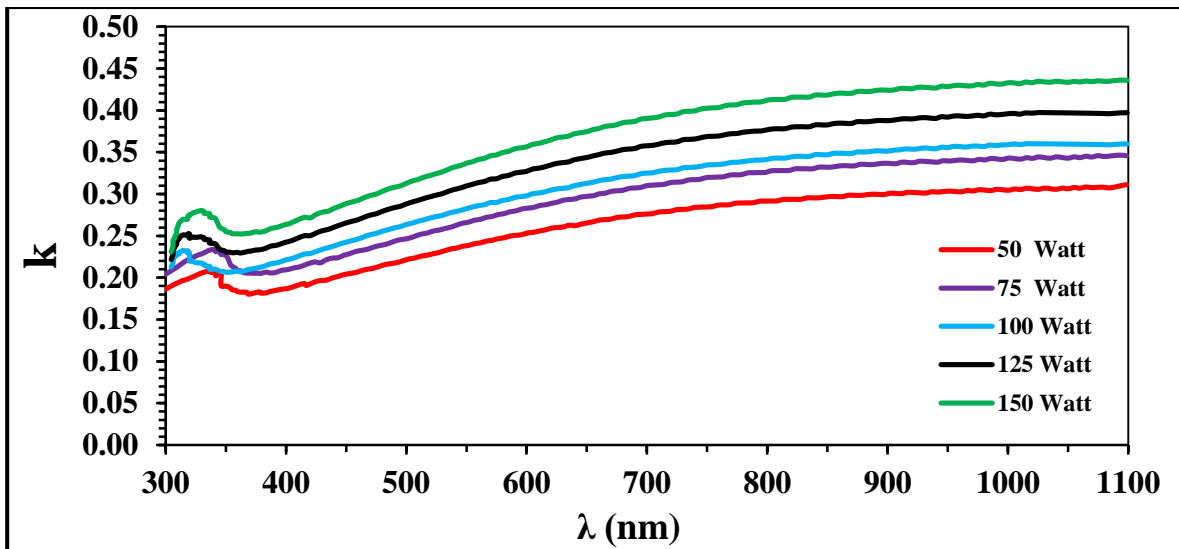


Fig. 5: Extinction coefficient as a function of wavelength for (Ti6Al4V) thin film at different working RF power.

Fig.6 and Fig.7 show the dielectric constant and dielectric loss as a function of wavelength for (Ti6Al4V) thin films deposited at different RF power. The dielectric constants decrease with increasing RF power, while they increase with increasing

wavelength (λ). The variation of the dielectric constant depends on the value of the refractive index. By contrast, the dielectric loss depends mainly on the extinction coefficient values which are related to the variation of absorption [13].

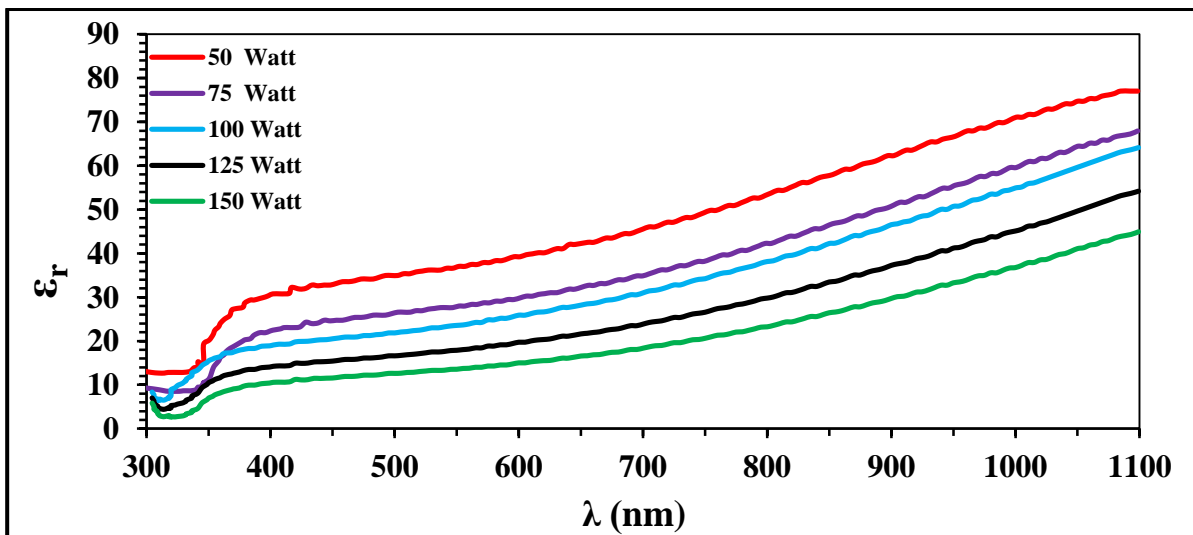


Fig.6: Dielectric constant real as a function of wavelength for (Ti6Al4V) thin film at different working RF power.

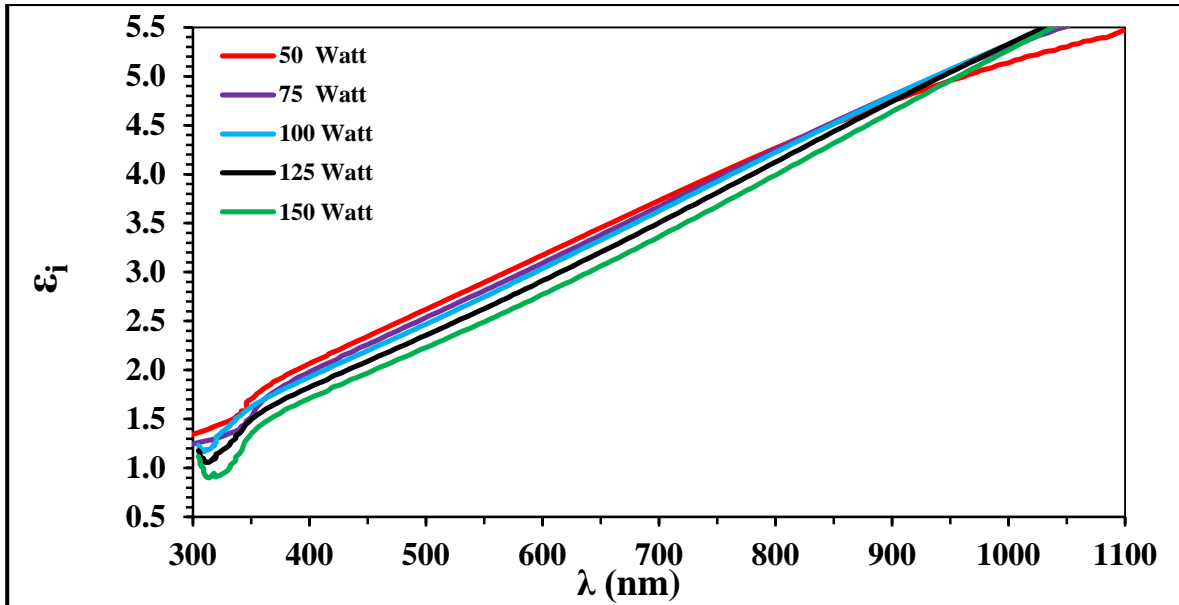


Fig. 7: Dielectric constant imaginary as a function of wavelength for (Ti6Al4V) thin film at different working RF powers.

The variation of the refractive index versus wavelength in the range (400–1100) nm, for deposited (Ti6Al4V) films on glass different RF power deposited on glass substrate. It is clear

from this figure that the refractive index in general increases with increasing thickness, due to the different in deposited thickness, as shown in Fig. 8.

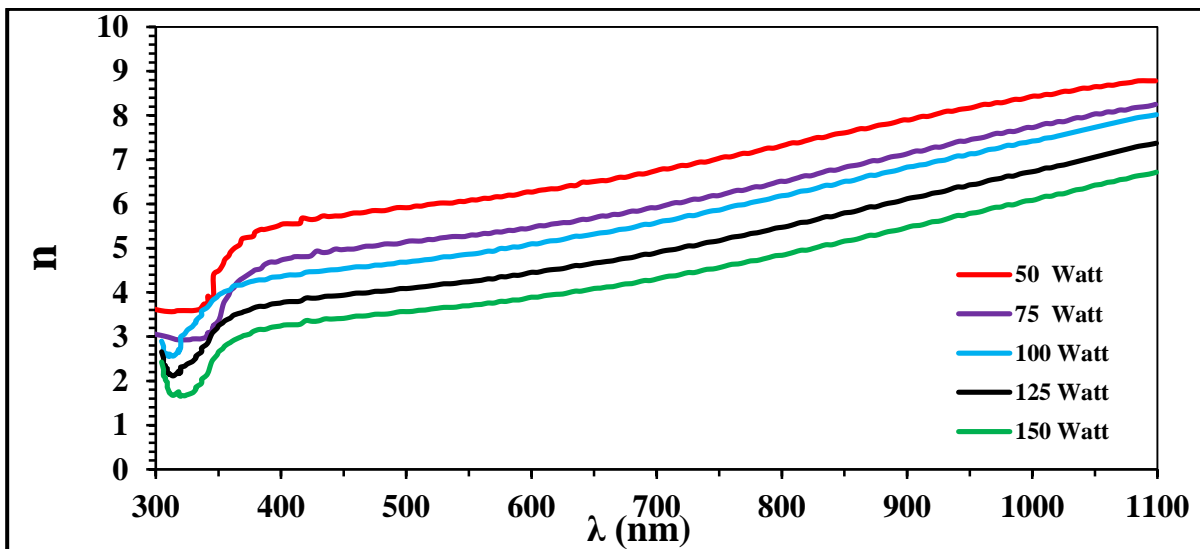


Fig. 8: Refractive index as a function of wavelength for (Ti6Al4V) thin film at different working RF power.

Table 1 shows the variation of optical parameters at 500 nm wavelength for (Ti6Al4V) films at different RF power. This table

illustrate that T , n , ϵ_r , ϵ_i and E_g decrease with increasing RF power while α and K decrease with it.

Table 1: The optical parameters for (Ti6Al4V) films at different RF power.

Power (W)	T(%)	α (cm ⁻¹)	K	n	ϵ_r	ϵ_i	E _g (eV)	Thickness (nm)
50	1.17	55621	0.223	5.916	34.953	2.633	1.54	244.89
75	0.71	61801	0.247	5.162	26.581	2.552	1.44	435.26
100	0.50	66222	0.264	4.682	21.850	2.468	1.39	598.98
125	0.31	72400	0.288	4.086	16.616	2.355	1.34	866.23
150	0.19	78578	0.313	3.565	12.613	2.230	1.23	910.46

Conclusions

The optical properties of deposited (Ti6Al4V) thin films by RF sputtering power technique with magnetron in argon at constant pressure (5×10^{-3} mbar) were studied at different powers. It's found that the films thicknesses increased with increasing applied voltage which leads to increasing the absorbance and the extinction coefficient (k) for deposited thin films, while another parameters such as dielectric constants and refractive index decrease with it.

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