Temperature effect on the formation of Ti_2O_3 in magnetron sputter deposition

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Thin film deposition is a way to change the surface properties of a piece without changing the bulk properties. Among the most used plasma techniques for film deposition, stands out the magnetron sputtering and its modifications like the grid assisted magnetron sputtering [1]. Titanium dioxide thin films have attracted great attention of scientific community due a wide range of applications of their different crystalline phases: anatase (A) and rutile (R) [2]. Other titanium oxides, like Ti_2O_3, are also of technological interest [3].

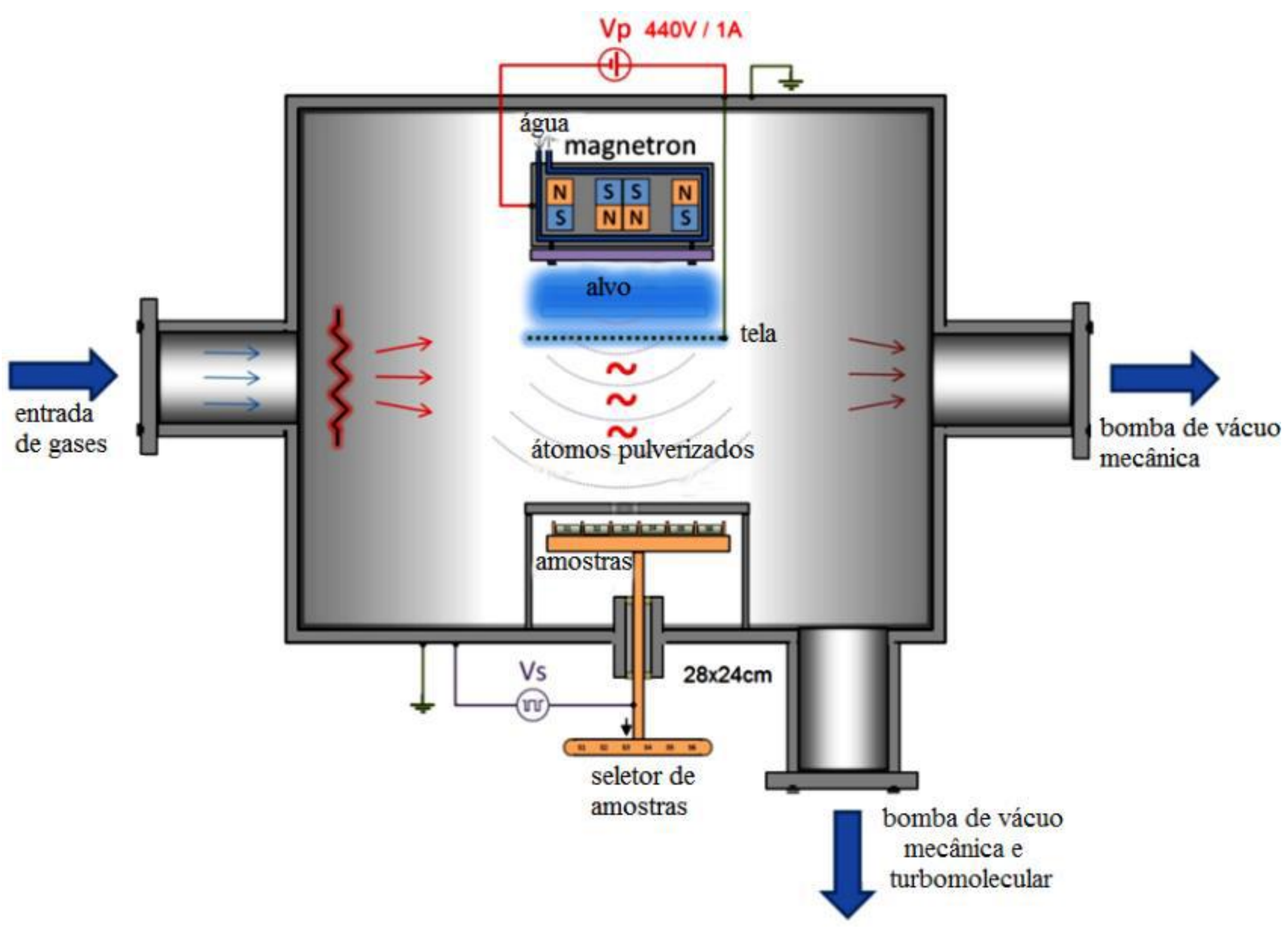

Fig. 1: Triode Magnetron Sputtering (LABPLASMA).

To verify how the substrate temperature affects the formation of titanium oxides, several films were deposited under different temperatures. The films were deposited on glass substrates. The substrates were biased to - 200 V at 5 kHz. All the depositions were realized just before the first critical point of the hysteresis curve [4], i.e. with the all the O_2 inserted in the reactor being consumed.

Tab. 1: Deposition conditions.

Deposition parameters	
Target	Ti (99.9%)
Base pressure	~ 10^{-2} Pa
Pressure	0.4 Pa
Grid-to-target distance	2.0 cm
Discharge power	470 W
Deposition time	30 min
Temperature	α (70°C), β (89°C), 100°C, 200°C, 300°C, 400°C

The films were analyzed by measurements of contact angle (before and after exposure to UV radiation - 253.7 nm) with deionized water and with diiodomethane.

The analysis by grazing incidence X-ray diffraction (GIXRD) shows the presence of the planes: A=Ti_2O_3 (012), B=A (011), C=R (110), D=Ti_2O_3 (104), E=A (112), F=R (111), G=Ti_2O_3 (202), H=Ti_2O_3 (024), I=Ti_2O_3 (116) and J=Ti_2O_3 (211). Others suboxide phases (K a Q) were also observed.

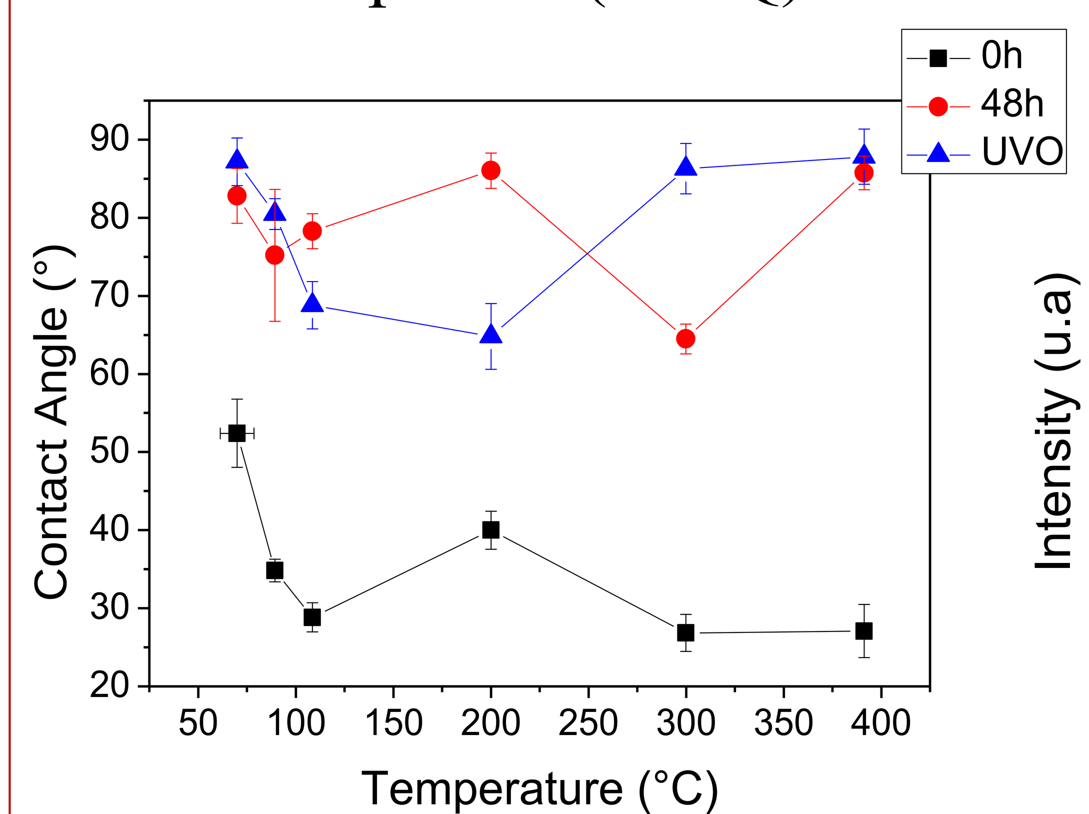

Fig. 2: Contact angle (UV off = UVO)

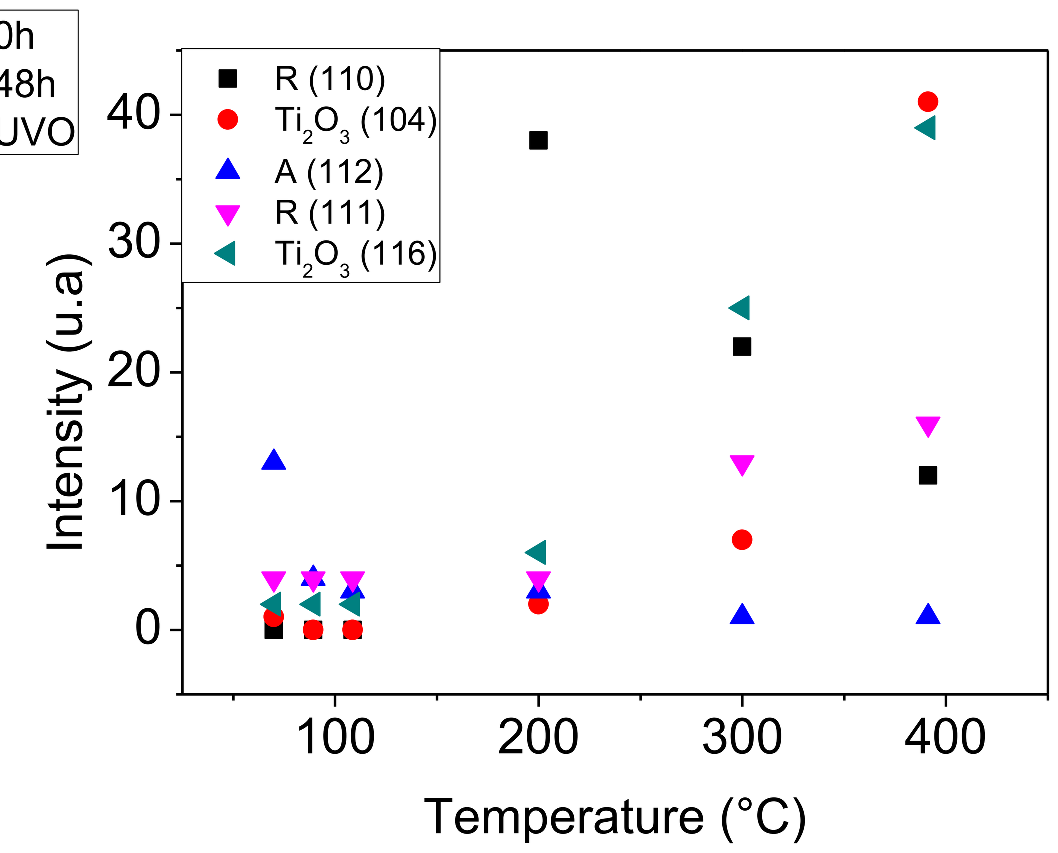

Fig. 3: Peak intensities as a function of temperature.

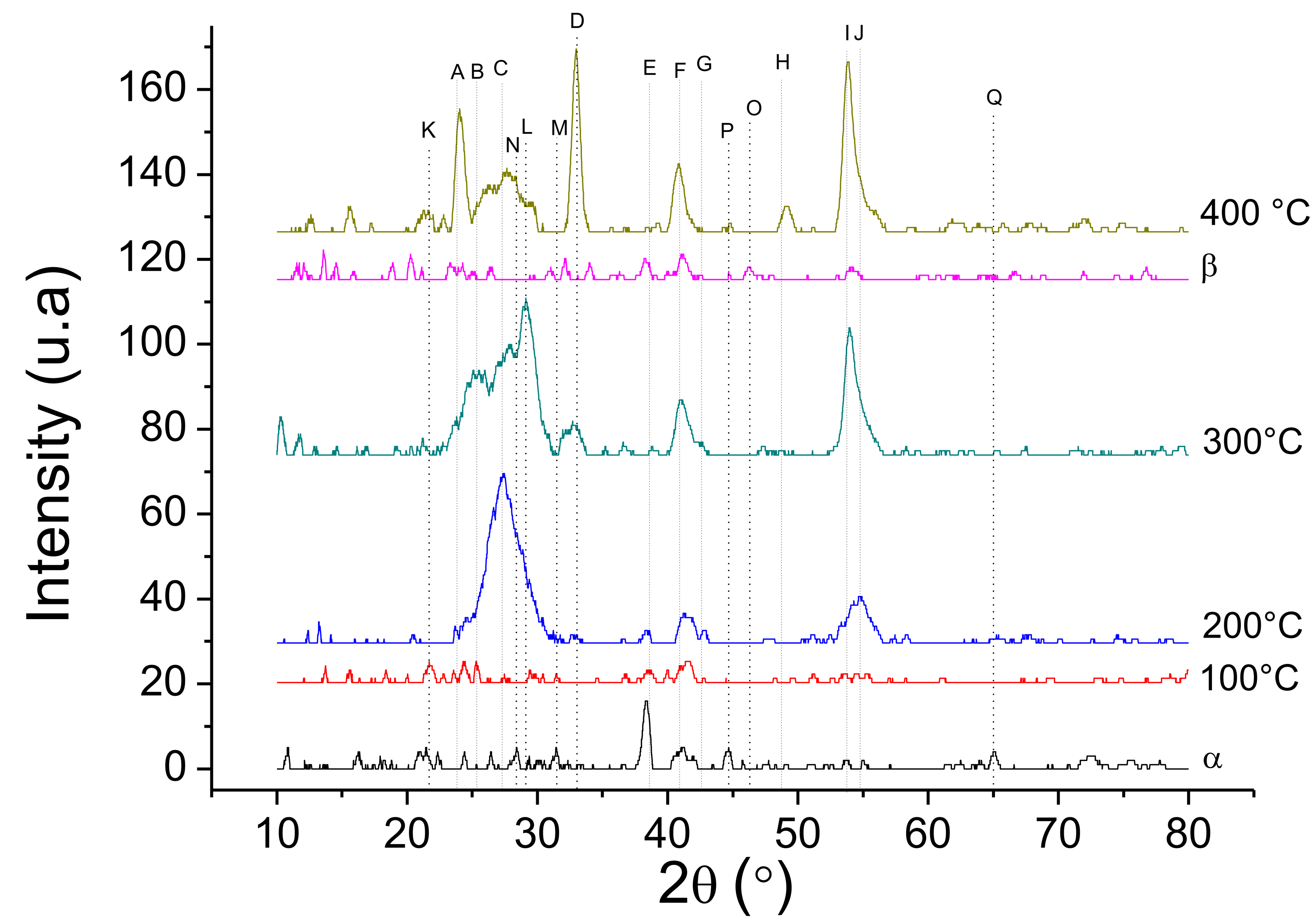

Fig. 4: GIXRD spectra.

For low temperatures the spectrum is dominated by A (112) and R (111) peaks. The spectra clearly show that for higher temperatures the most intense peaks are related to Ti_2O_3. The plane Ti_2O_3 (024) is observed only for 400 ºC. The growth in Ti_2O_3 peaks with temperature can be attributed to the increased oxygen desorption from film surface during deposition, although a deeper investigation is necessary to confirm this hypothesis.

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References:

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