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Effect of Deposition Parameters on Morphology and Optical Properties of Multilayer Selective Solar Surfaces (Mo/Si)

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I. Introduction

Energy consumption to meet the needs of society has increased significantly over the years and, consequently, the intensive use of fossil fuels. In this context, the search for clean energy sources has been shown as an alternative to minimize the environmental impacts. Among the renewable sources of energy, solar stands out, whose use can be made by thermal conversion through the solar collector. An effective method to increase the performance of a collector is to incorporate a selective surface, so that it allows the efficiency of this equipment to increase, enabling it to operate at a higher temperature [1] [2]. Selective surfaces are materials that have selective reflectivity, i.e. capable of absorbing the maximum amount of incident solar radiation and minimizing thermal losses due to the emission of infrared radiation [3].

Therefore, the objective of this work is to obtain selective surfaces with a single layer of Molybdenum (Mo) and multilayer of Mo and Silicon (Si) using the *Magnetron Sputtering* technique with different deposition parameters and using substrates that have undergone the surface treatment of electropolishing, in order to eliminate scratches and marks present on the surface, ensuring uniformity and a better finish for it.

II. Methodology

The entire process of setting parameters can be seen in Fig. 1.

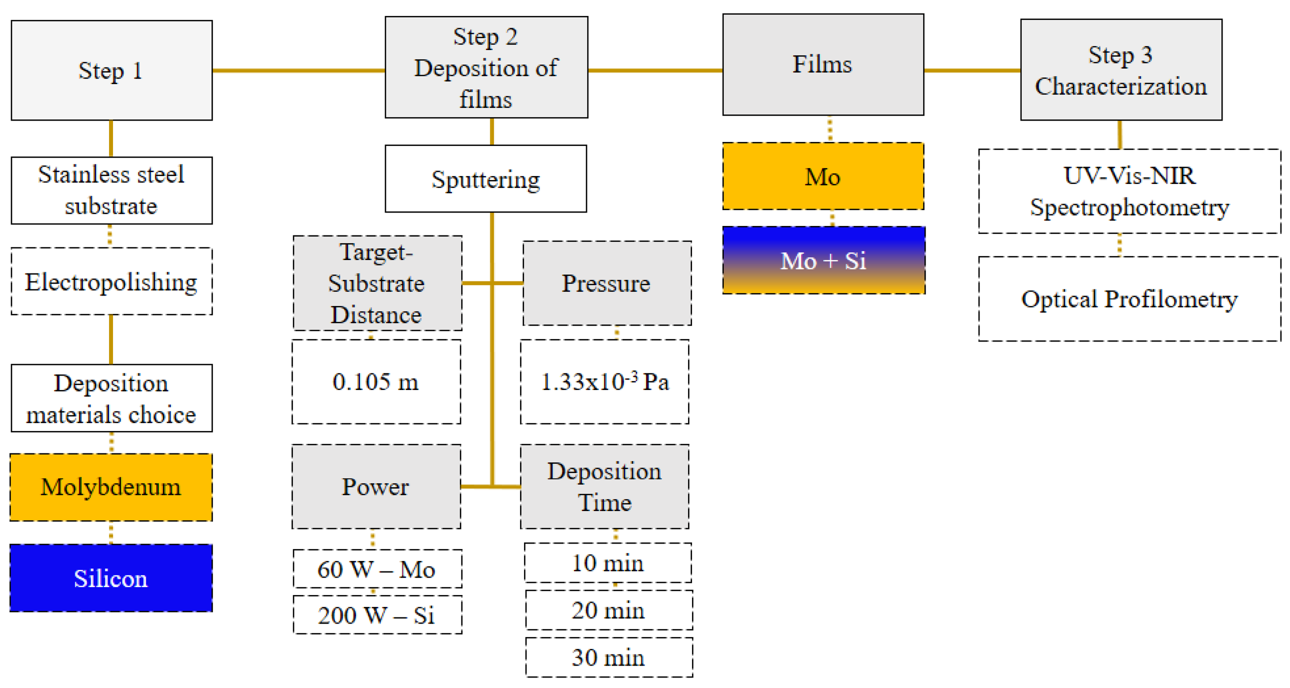

FIGURE 1. Experimental Process Flowchart.

Based on the different parameters adopted in the depositions, 6 conditions were obtained, according to Table I.

TABLE I: Samples Nomenclature

Sample	Composition	Deposition Time (min)	Sample	Composition	Deposition Time (min)
S1		10	S4		10/10
S2	Mo	20	S5	Mo+Si	20/20
S3		30	S6		30/30

III. Results And Discussion

A. UV-Vis-NIR Spectrophotometry

The absorber and multilayer films (Mo, Mo/Si) obtained by *Magnetron Sputtering* with different parameters, were subjected to radiation with a wavelength in the range of 220 nm to 1400 nm (UV-Vis-NIR) in order to determine their spectral absorbances, allowing the plotting of the following curves shown in Fig. 2A.

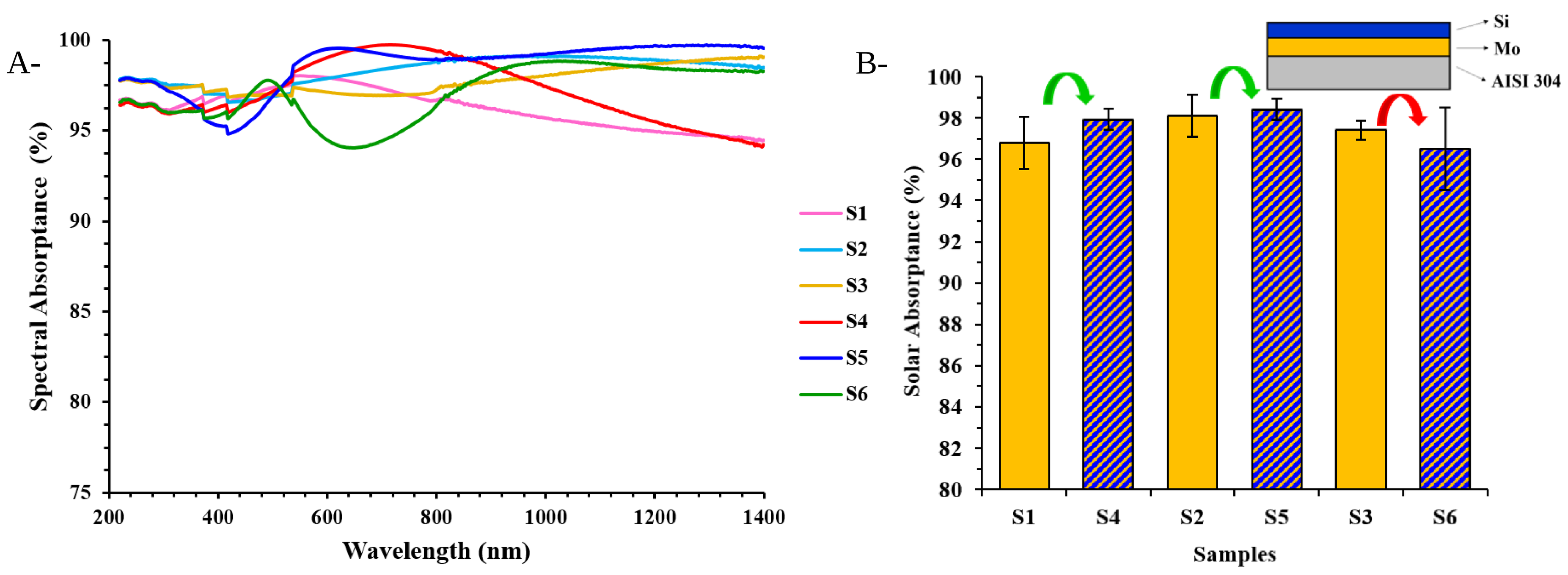

FIGURE 2. A- Absorptance spectrum of Mo and Mo/Si films deposited on electropolished substrates.
B- Solar absorptances and their respective standard deviations.

It is also observed that the spectrum of the films shows a very harmonic behavior almost constant throughout the wavelength studied, revealing that the electropolishing on stainless steel substrates provides excellent optical stability to the films produced. The addition of the Silicon antireflective layer in the Molybdenum film on the substrate AISI 304 favored the increase in the absorbance of the films that were deposited during 10 and 20 minutes, as can be seen in Fig. 2.B.

B. Optical Profilometry

All films were subjected to optical profilometry analysis, from which the following parameters were obtained: Ra and the thickness values of the films. In the data obtained, for the Ra parameter a range of 0.0115 to 0.0279 µm and for the roughness, values of thickness between 0.170 to 0.218 µm was noted for the Molybdenum absorber films, whereas for the multilayer films was observed a variation of 0.0223 to 0.0450 µm and 0.272 to 0.462 µm for multilayer samples.

In Fig. 3, it can be seen that the solar absorption of the films slightly rises with the increase in roughness. However, when the surface exhibits Ra values close to or greater than 30 nm, the solar absorptivity starts to decrease, as is the case of the S6 sample that presented the highest Ra (45 nm) with the lowest solar absorption (96.51%). So that films with rougher surfaces (≥ 30 nm) are likely to exhibit less absorption.

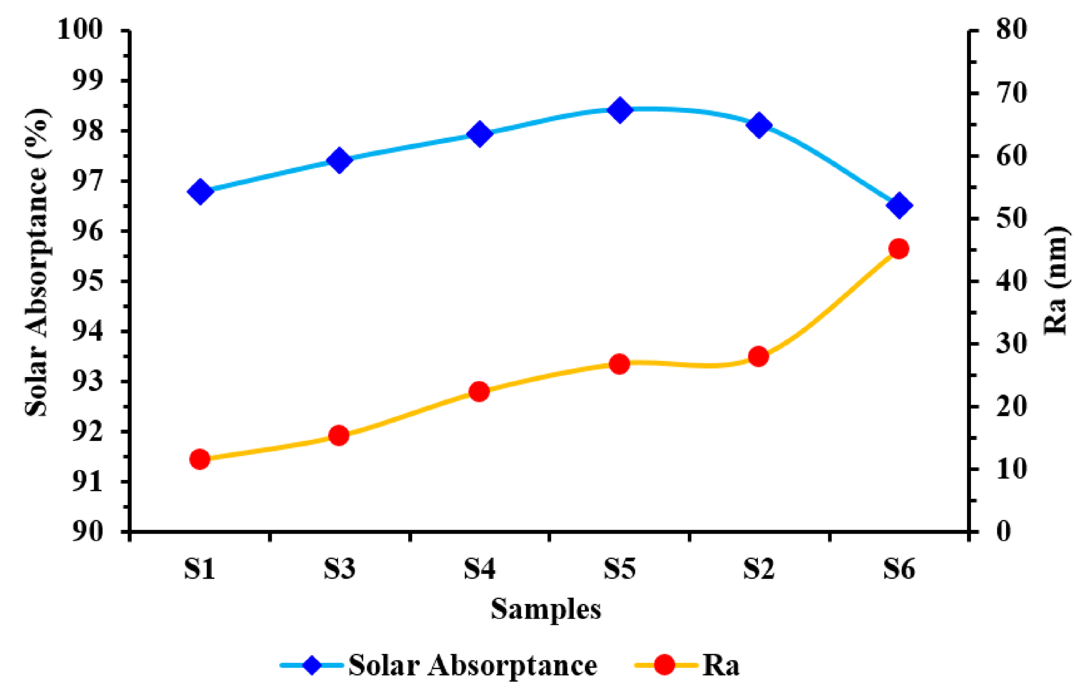

FIGURE 3. Correlation between the Ra parameter and the solar absorption of the films.

The Fig. 4 shows the 3D morphology of the surfaces of films deposited on substrates subjected to electropolishing, a treatment in which it provided low surface roughness (15 to 45 nm), which reveals its abrasive character. In addition, it is possible to see that the surface roughness rises with the addition of Si on the Molybdenum layer for most cases, especially when deposited for 30 min, as seen from the S6 profile.

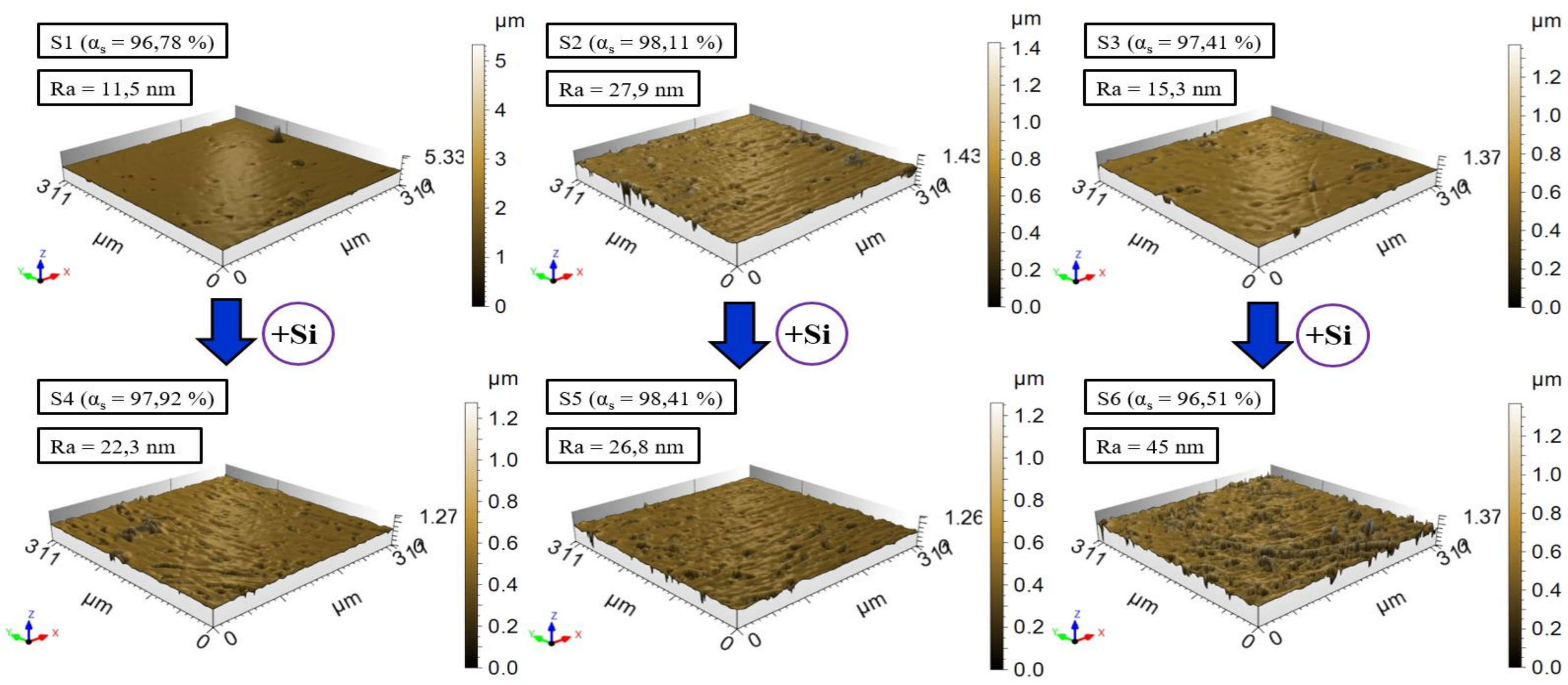

FIGURE 4. 3D Morphological profiles of films with single layer of Mo and with multilayer of Mo/Si.

IV. Conclusions

The electropolishing was a very effective surface treatment, as it ensured high levels of solar absorption (96.51% - 98.41%) for all samples with excellent absorption stability through the spectrum. Due to the deposition technique used and the abrasive nature of the treatment, the films presented homogeneous morphological profiles, which resulted in smoother surfaces and with small Ra values. This may have contributed to the high levels of absorption. And the multilayer film with the deposition time of 20 minutes (S5) obtained the best result, reaching a solar absorption of 98.41%, which characterizes it as an excellent solar absorber. Therefore, it is observed that the films produced are excellent candidates to be applied as selective solar surfaces, due to the high absorbances, good absorption stability and their surface being microstructurally homogeneous.

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