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Composite spinel oxides films on stainless steel for high-temperature solar absorber

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ABSTRACT

Composite spinel oxides films on SS were an attractive material for high temperature solar absorber. This present study is aimed at developing a high-temperature solar absorber coating by using a simple and low-cost fabrication technique. The composite Spinel oxides films formed on stainless steel (SS304) substrates to be absorbers by high thermal process at 950 °C. In order to enhance the solar absorptivity and isolate external environment, different thickness of titanium dioxide (TiO2) coating such were deposited on the top. X-ray diffraction (XRD), X-ray Photoelectron Spectroscopy(XPS), scanning electron microscopy (SEM), UV/visible spectroscopy (UV–vis–NIR Spectrophotometer, 0.30-2.5μm) and Emissometer analyses are conducted to study the crystalline structure, surface morphology of the solar absorbers and optic properties of the films. For the solar absorber deposited with an optimal TiO2 thin film coating, the absorptivity is 0.921 and the emissivity is 0.342.

Keywords: solar absorber, high temperature, stainless steel, anti-reflective coating, titanium dioxide

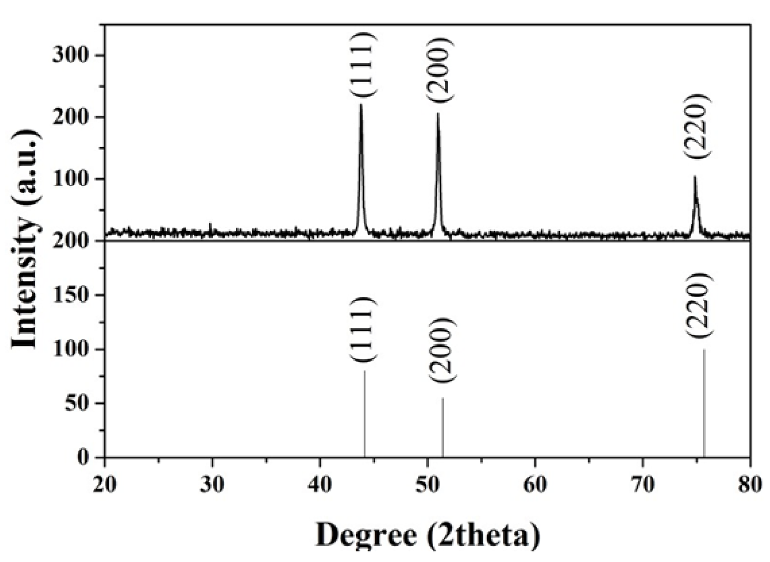

Figure 1 XRD analysis of SUS304 stainless steel substrate

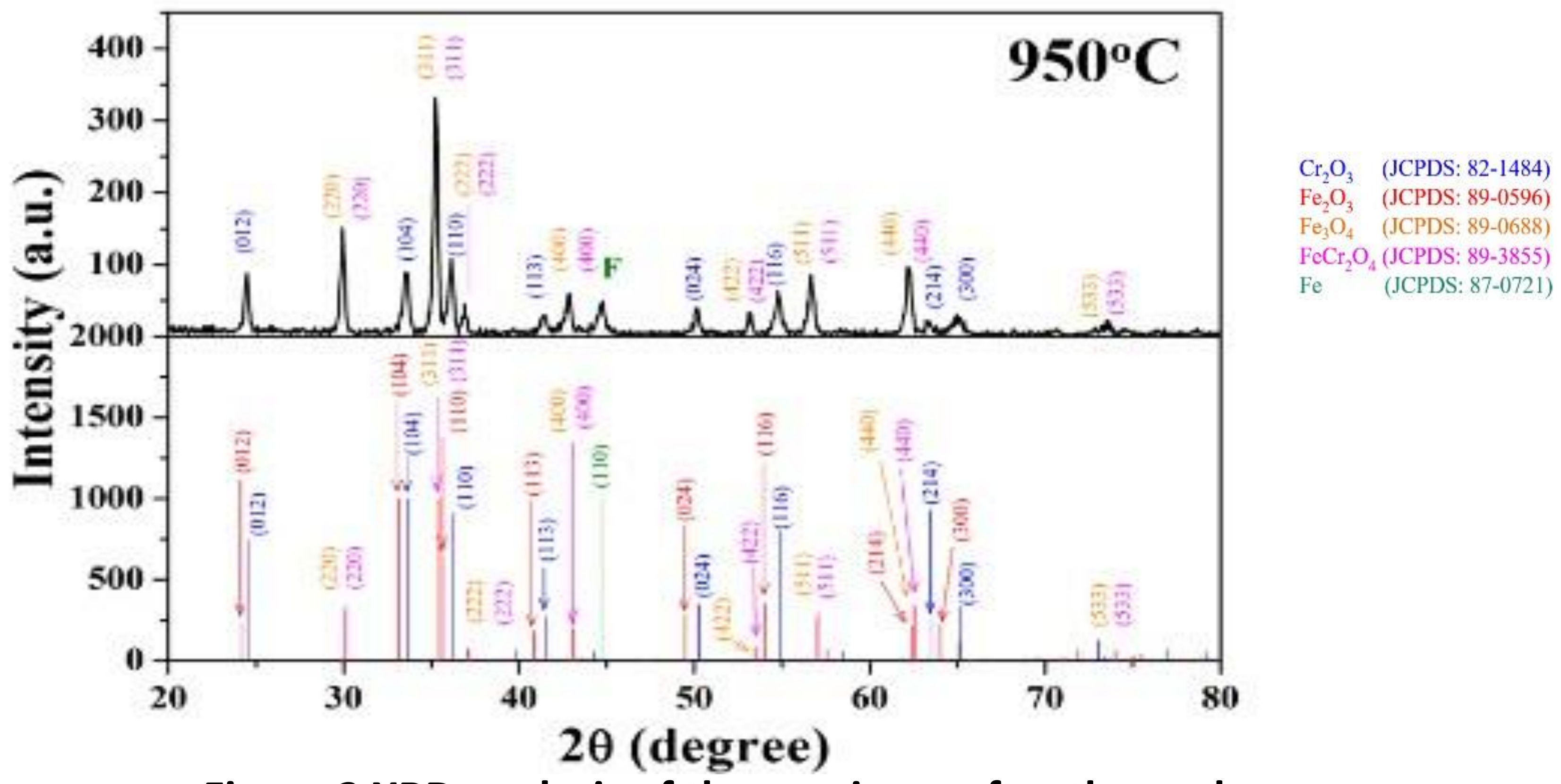

Figure 2 XRD analysis of the specimen after thermal oxidation treatment

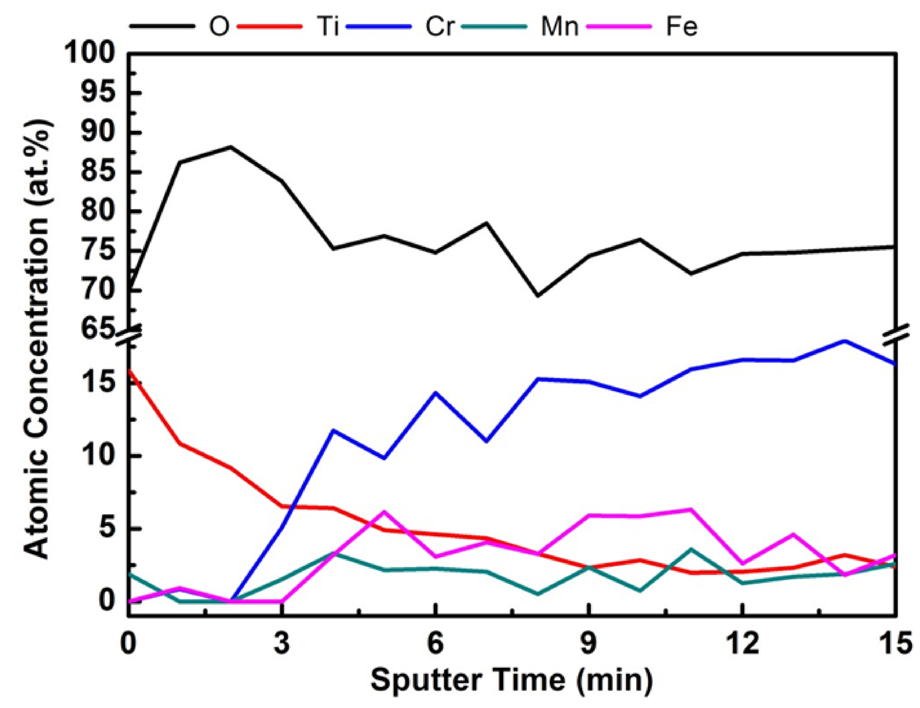

Figure 5 XPS depth analysis of deposited 30 nm TiO2 film

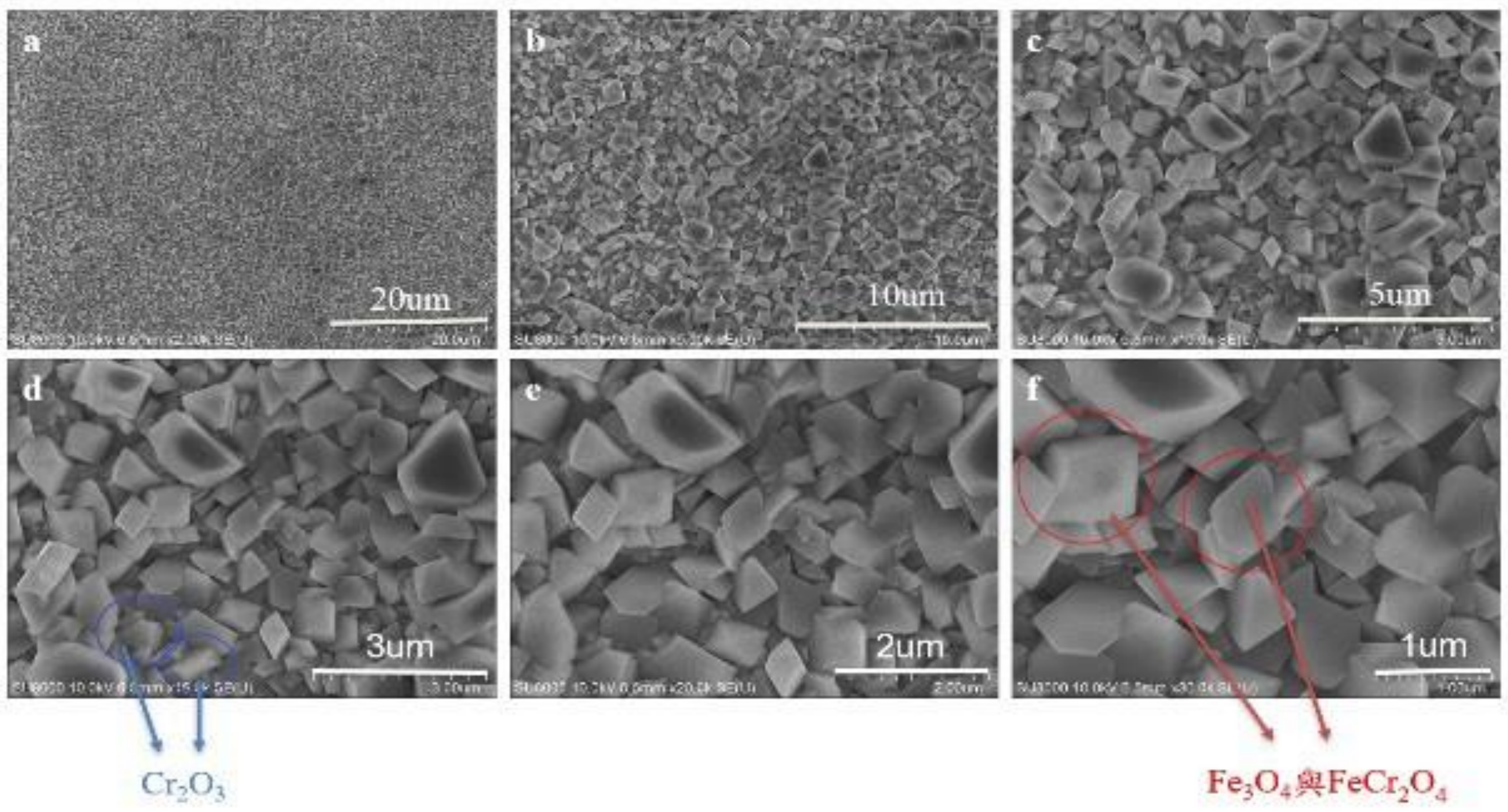

Figure 3 SEM image of the specimen after thermal oxidation treatment

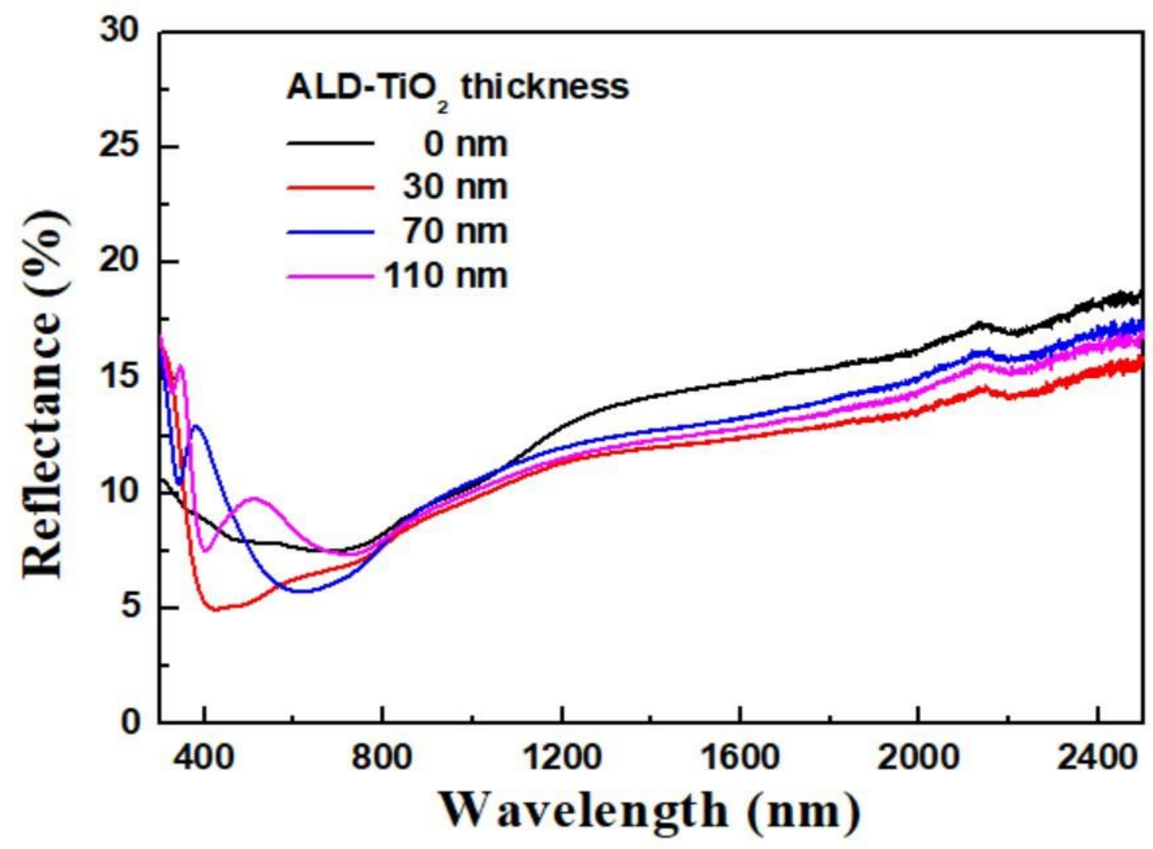

Figure 6 Spectral reflectance diagram of different TiO2 thicknesses

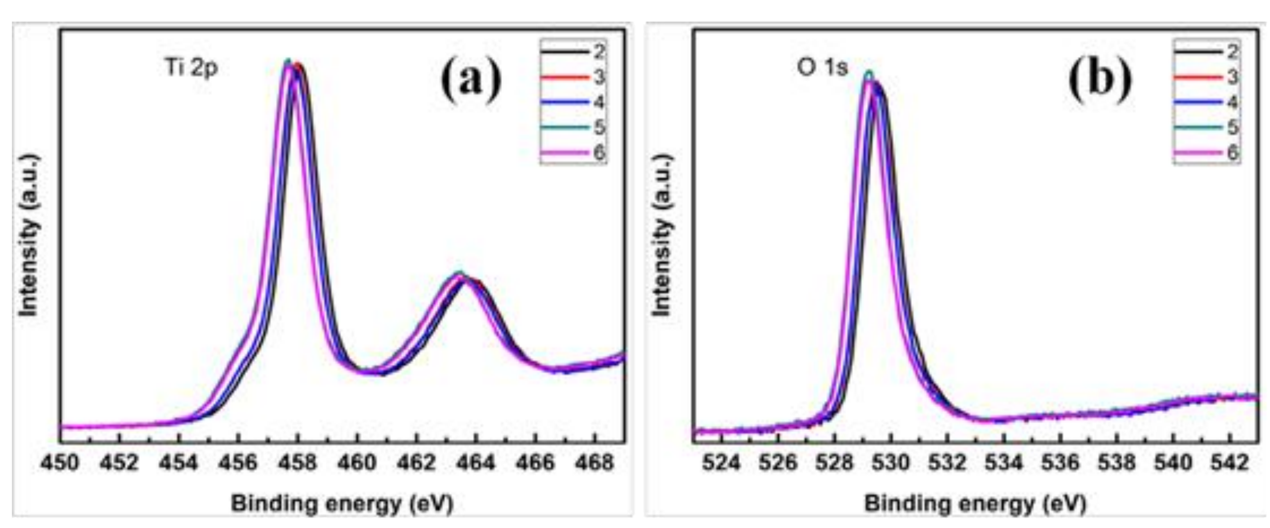

Figure 4 TiO2 films deposited with different thicknesses (a) Energy spectrum of Ti element (b) Energy spectrum of O element

Table 1 Comparison of absorptivity and emissivity of solar absorbers

	0nm-TiO2	30nm-TiO2	70nm-TiO2	110nm-TiO2
Absorptivity	0.901	0.921	0.909	0.903
Emissivity	0.334	0.342	0.475	0.492

Conclusions

1. The main characteristics of the stainless steel substrate composite high-temperature solar absorption film produced in this study are absorptivity (0.901~0.921) and emissivity (0.334~0.492). Its characteristics are not only better than those of commercial products, but also better than those of transition metal spinel oxide/stainless steel (SS304) high-temperature absorption film developed by American Sandia National Laboratories with an absorption (0.90~0.92) and an emissivity (0.49~0.60).
2. This study found that Fe3O4 and FeCr2O4 spinel oxide films can be produced on stainless steel (SS304) at 950°C by using the method of the Republic of China patent I593804 "Preparation method of light absorbing elements" which is belongs to National Cheng Kung University.
3. As the thickness of the TiO2 film increases, its solar light absorption rate increases compared with that before uncoating. Its changing trend decreases as the thickness increases, but the emissivity also increases. The optimal thickness is 30nm, and the absorption rate is 0.921, and the emissivity is 0.342.