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Single Layer of an Electron Beam Evaporated TiO_xN_y as Selective Solar Absorber

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Extended Abstract

The world's energy demand is increasing with economic and population growth. However, the current energy supply relies heavily on fossil fuels, which contribute significantly to greenhouse gas emissions and global warming. Therefore, reducing greenhouse gas emissions is crucial to mitigating global warming. This requires the development of better technologies that utilize renewable resources. The sun plays a vital role in sustainable energy production. Currently, solar energy is converted into electricity through photovoltaic devices. Another important technology involves absorbers that convert solar radiation into thermal energy. Solar-thermal systems are considered the most promising for harnessing abundant solar energy. An ideal absorber should have high absorptance in the ultraviolet (UV), visible, and near-infrared (NIR) regions (0.3 – 2.5µm) and low thermal emittance in the infrared (IR) region beyond 2.5µm [1]. Solar absorber surfaces can be designed in various structures, including intrinsically selective materials, semiconductor-metal stacks, metal-dielectric stacks, and textured surfaces [1]. Recently, titanium oxynitride (TiO_xN_y) films have gained increasing interest due to their unique properties that make them suitable for a wide range of applications. These properties depend on the tuneable N/O ratios between metallic titanium nitrides and dielectric titanium oxides [2].

This study aims to prepare a single layer of TiO_xN_y thin film deposited onto copper, silicon, and glass substrates using E-beam evaporation with varying oxygen partial pressures. The effect of oxygen partial pressure on the structural, optical, and electrical properties has been investigated. XRD diffraction patterns confirmed the (111), (200), and (220) orientation of the TiNx phase. The preferred orientation of the films changed with oxygen partial pressure. XPS revealed that the intensity of both Ti 2P3/2 and Ti 2P1/2 increased as the oxygen flow increased, and they also shifted toward higher binding energy, indicating a more oxidized state of Ti species compared to TiO_2, which can be attributed to the incorporation of nitrogen atoms. The formation of uniformly distributed particles and an increase in surface roughness of the TiO_xN_y films were observed as the oxygen partial pressure increased. Ellipsometric and resistivity measurements showed a transition from metallic to semiconductor behavior of the TiO_xN_y films with changes in oxygen flow. TiO_xN_y solar absorber coatings prepared at an oxygen partial pressure of $7.5x10^{-5}$ Torr achieved a solar absorptance value of 0.94 in the solar spectrum region and a low thermal emittance value of 0.05. This was attributed to both interference and intrinsic absorption. This study confirms that a single layer of TiO_xN_y film can be a good candidate for a selective solar absorber.

References

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