Abstract

Solar energy is one of the most abundant renewable energy sources, which can be converted (i) directly into electricity using solar photovoltaic, and/or (ii) into thermal energy, which later can be used for numerous applications including electricity generation. The latter one is called as solar thermal technology, where Sun energy is concentrated onto a receiver for its maximum absorption with minimum thermal emission in the desired spectral range simultaneously for efficient conversion into thermal energy. An ideal spectrally selective absorber surface exhibits absorptivity "$\alpha \sim 1$" in the solar wavelength range and emissivity "$\varepsilon \sim 0$" in the infrared wavelength range to convert the entire incident solar irradiation into thermal energy, without any thermal loss. Thus, the development of such spectrally selective coatings is essential to meet the requirement. In addition, these coatings should withstand high operating temperatures and large thermal cycling, without any significant degradation in their solar thermal performance.

Black chrome ($Cr-Cr_2O_3$) is one of the most extensively studied and commercialized spectrally selective absorber coatings for photothermal applications. Nevertheless, corrosion and thermal stability of black chrome coating are still challenging. The work has focused on improving the corrosion and thermal stability by introducing the nanoparticle (NP) in the black chrome spectrally selective coating matrix. The graphite encapsulated FeCo NPs are used in the black chrome electrolytic bath to synthesis FeCo(C) NPs modified black chrome thin films. These modified black chrome thin film structures have showed enhanced thermal stability and corrosion resistance, as compared to pristine black chrome structures. In addition, the work has also focused on design and development of reflector-absorber tandem spectrally selective coating structures for high temperature applications. These are based on Zr refractory material as a reflector in conjunction with ZrC-ZrN absorbers. The developed ZrO_x/ZrC-ZrN/Zr/substrates structures suggest that these coatings can be used upto 700°C in vacuum on SS substrates and upto 200°C in ambient conditions without any significant degradation in their solar thermal performance. The corrosion studies on these structures are carried out in 3.5 wt.% NaCl electrolyte solution and observed that these structures are highly corrosion resistance. The corrosion rate is ~ 0.000054 (mm/y), which is much lower, as compared to both stainless steel and copper substrates. These studies suggest that the developed ZrO_x/ZrC-ZrN/Zr structures may be used for high temperature applications under the adverse conditions such as saline environments.

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