Abstract

This thesis describes research on coatings for concentrated solar power (CSP) receivers, conducted to increase their efficiency for solar-to-thermal energy conversion and prolong their service lives. The coatings for CSP receivers include a black spinel pigment with a high absorptance for sunlight. With aim to develop pigments with an even higher solar absorptance (α_S), metal ions were added to the commercial pigment and, using solid-state synthesis, new compositions were formed. The pigment doping resulted in a reduction of the thermal emissivity (ε_T) and therefore the efficiency of the receiver increased. The prepared coatings were thermally aged for 1300 hours at 800 °C in air, and the characterization was performed at uniform time intervals. Excellent results were obtained with the coatings made from the Cr-doped pigment.

Coating-reliability testing was conducted to evaluate the service life of the high solar absorptive (HSA) coating under conditions simulating those in industry. To improve the corrosion resistance of the CSP receiver at high temperature, while maintaining the low thermal emission of the coating, ultra-thin (1–3 nm) mono-, di- and trilayers of hybrid organic-inorganic polyhedral oligomer silsesquioxanes (POSS) were prepared with the Langmuir-Blodgett (LB) technique.

Alumina thermal barrier coatings with a low ε_T were fabricated using the sol-gel process and HSA coatings on the basis of a SiO_2 inorganic binder were deposited on them. Alumina coatings were also laser-cured, which increased their thermal stability. New, two-dimensional materials such as MXenes were used in the preparation of the coatings to improve their functionality.

Keywords: concentrated solar power, spectrally selective coatings, reduced thermal emittance, spinel pigment, metal ion diffusion