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Conclusion and Future Work

The thesis work summarizes the importance of spectrally selective absorber coatings for solar thermal applications. The solar thermal conversion efficiency highly relies on the optical performance of these spectrally selective absorber coatings at elevated operating temperature conditions. SSAC needs to exhibit high corrosion resistance to avoid the degradation in its optical performance over a longer operational period under ambient conditions. Further, due to the limited availability of commercial SSAC structure and limitation in fabricating technology, there is a need for the development of efficient SSACs, which can sustain their optical performance at higher temperatures for longer duration in open environment conditions. With this objective, we have optimized the black chrome deposition conditions for larger surfaces and discussed the associated challenge. BC as SSAC with absorptance and emittance ~ 95% and ~ 0.14 respectively were successfully coated on radiation calorimeter (RADCAL) devices developed for solar irradiance measurements. Further, Ni, Co co-pigmented anodized nanoporous alumina structures are developed using a low-cost electrodeposition process, and the optimized absorptance and emittance values are ~ 95% and ~ 0.14, respectively. These structures showed thermal stability up to 300°C in open environmental conditions, together with enhanced corrosion resistance compared to the reported Ni pigmented structure. The absorptance after heat, as well as corrosion treatments, remained nearly the same, whereas emittance increased up to ~ 0.2 and ~ 0.38, respectively. Thus, Ni, Co co-pigmented anodized alumina as the spectrally selective coating may exhibit better stability compared to Ni pigmented structure in the mid-temperature range up to 300°C.

The W/SS thin film was fabricated and optimized for its optical response using sputtering. The W thickness in the micrometer range, deposited at a higher temperature, showed lower emittance. Further, W/SS thin film with low oxide content showed the optimal thermal emittance ~ 0.13 compared to the sample with relatively higher oxide content. The intrinsic Interband transition in tungsten and plasmonic absorption around 1.75 eV in visible range and formation of oxide collectively limit the emittance of W/SS thin film near ~ 0.1, and probably lower thermal emittance values are not possible for pristine W thin films.

Also, to develop an alternative SSAC structure to corrosion-prone most common metal-dielectric SSAC, all oxide-based $SiO_2/(ZnO/Sn\text{-}In_2O_3)_{n=4}/SS$ multilayer structure is developed and optimized using simple and low-cost sol-gel dip coating. To achieve the same, we developed a semi-automated dip coating system at IIT Jodhpur. The estimated absorptance and emittance for the fabricated structure is ~ 0.85 and 0.14, respectively.

The present thesis work opened new avenues to explore as future work to achieve high-temperature SSACs for different applications. For example, we explored W as an IR reflector layer, but its intrinsic physical properties limit the thermal emittance by 0.1, and lowering further may not be possible. Thus, there is a need to explore low thermal emittance materials, which are stable at high temperatures. We first time demonstrated the possibility of all oxides based SSACs. However, its performance is still not up to the mark. It provides a new platform to explore the various oxide semiconductors especially low bandgap semiconductors so that the optical properties can be enhanced to the desired level together with their stability against temperature and open ambient conditions. Thus, replacing In_2O_3 by low bandgap material such as CuO, Co_2O_3, NiO, etc. the absorptance can further be increased. By integrating low-cost infrared layer suitable for high temperature on a metallic substrate, the emittance can be lowered to minimize the thermal losses as well. Last, but not the least, the present work also provides a way to explore high thermal and chemical stable antireflection coatings to avoid back reflection and thus to maximize the optical performance of the SSACs. The developed low-cost dip-coating process also needs to be explored to realize the development of practical coating structures to meet the solar thermal requirements.