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Conclusion and Scope of the Future Work

Spectrally selective absorber surface is one of the most important components of the solar thermal energy technologies/systems. The higher operating conditions of receivers, consisting of absorber coatings, will enhance the solar thermal efficiency and reliability of the systems. Considering the same, different types of spectrally selective absorber surfaces have been modified/developed using different synthesis techniques. This includes:

1. The modification of black chrome spectrally selective structures with as graphite encapsulated FeCo nanoparticles for mid-temperature solar thermal applications. The important developments are:
   1.1 The modified FeCo(C) NPs black chrome structures are thermally stable up to ~ 400°C or more in open ambient conditions.
   1.2 The modified FeCo(C) NPs black chrome structures exhibit relatively larger corrosion resistance ~ 0.1968 KΩ as compared to pristine black chrome selective surface ~ 0.06684 KΩ (on the copper substrate) and thus can be used under extreme environmental conditions.
   1.3 0.1 wt.% FeCo(C) NPs modified black chrome selective coatings, corrosion rate reduces to half (6.564 mm/y), as compared to the pristine black chrome (11.08 mm/y) selective coatings

2. The design and development absorber-reflector tandem (ZrO_x/ZrC-ZrN/Zr) selective structures for high temperature applications. Some of the important developments are
   2.1 Optimization of metallic zirconium (Zr) layer for minimum thermal emittance (~ 0.12) in the desired wavelength range (2.5 – 25 μm). The optimized deposition condition includes DC sputtering of Zr infrared reflector at 350°C deposition temperature for 2 hours.
   2.2 Optimization of ZrC-ZrN absorber layer using RF sputtering at different nitrogen flow rates during absorber deposition. The optimized absorber layer showed absorptance ~ 0.88 and the corresponding emittance is ~0.04 for ZrO_x/ZrC-ZrN/Zr structures on SS substrates.
   2.3 The mechanical properties such as Young's modulus and hardness of tandem absorber structure (ZrO_x/ZrC-ZrN/Zr) showed a strong dependence on growth conditions of the absorber layers and found that moderate Young's modulus and hardness are important for enhanced solar thermal performance.
   2.4 These ZrO_x/ZrC-ZrN/Zr structures are thermally stable up to ~ 700°C on SS and 600°C on Cu substrates in vacuum, and up to 200°C in air.

The impact of corrosion on this absorber-reflector tandem structure (ZrO_x/ZrC-ZrN/Zr) in 3.5 wt.% NaCl saline environments has been investigated. It is observed that ZrO_x/ZrC-ZrN/Zr structures on SS or Cu substrates exhibit larger corrosion resistance ~ 1379 kΩ, as compared to bare stainless steel and copper substrates. Thus, ZrO_x/ZrC-ZrN/Zr structures can be used under adverse environmental conditions with enhanced thermal and corrosion reliability.

The developed spectrally selective coating structures during these studies may further be subject to the development of thermally stable structures on specific substrates such as cylindrical pipes or other curved surfaces for realizing the probable applications in real systems. The work can be extended to develop:

1. The low cost deposition techniques such as electrochemical deposition, spray coating technique, dip coating and sol-gel techniques for the realization of large scale spectrally selective absorber surfaces.
2. FeCo(C) NPs modified black chrome selective coatings can be developed for large scale absorber tube employing electrodeposition techniques for high temperature applications in inert or open air ambient.
3. Absorptance of the zirconium carbonitride (ZrC-ZrN) absorber layer can further be enhanced with varying absorber layered structures and oxide based absorbers may be developed for enhanced thermal and corrosion stability.
4. The absorber–reflector (ZrOx/ZrC-ZrN/Zr) tandem structure can be developed large scale coating employing sputtering system.

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