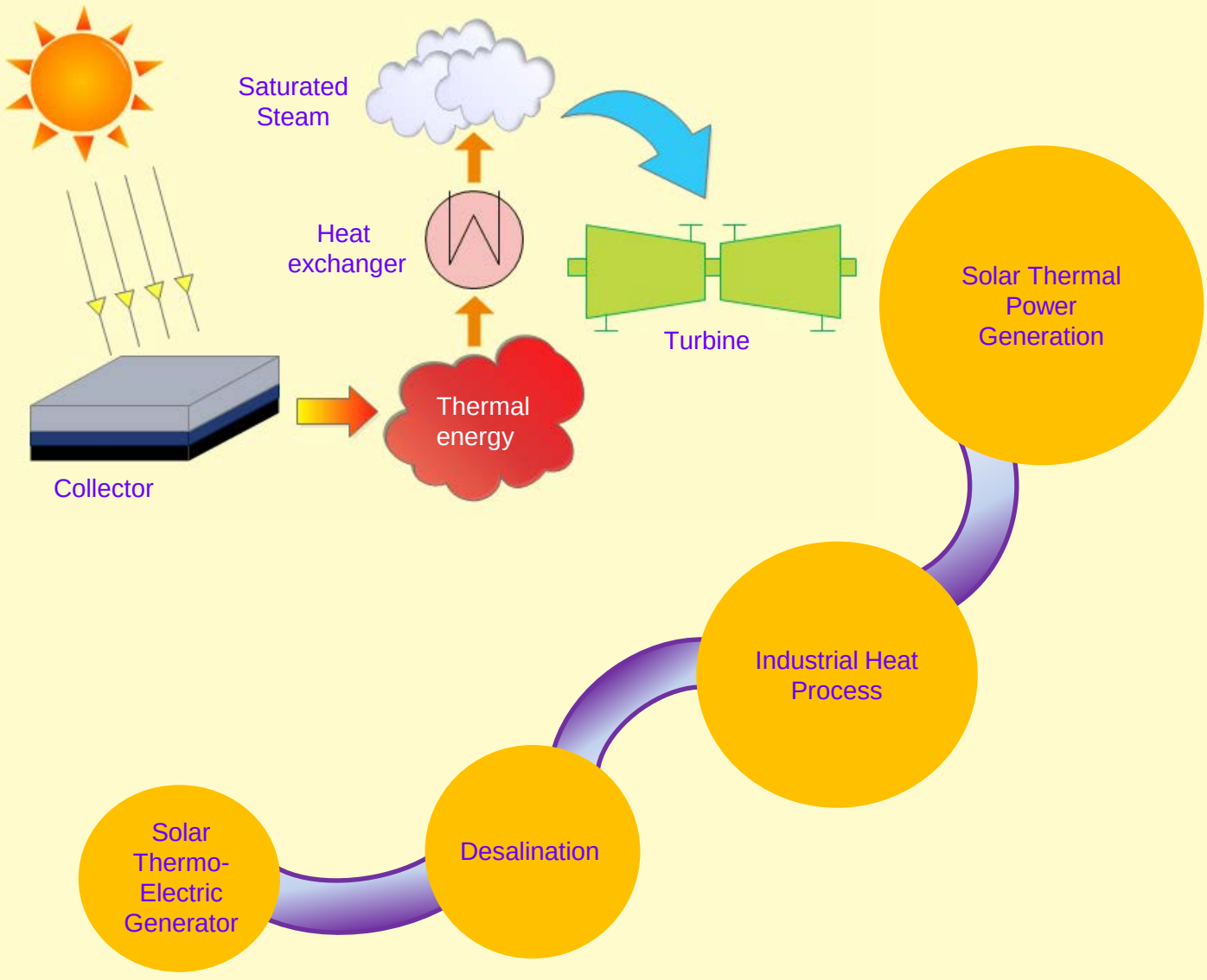
Spectrally Selective High- Temperature Solar Absorber Coating Technology



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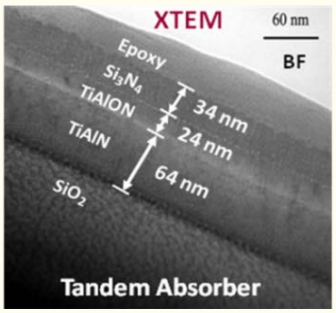
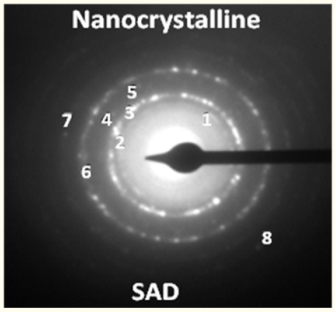
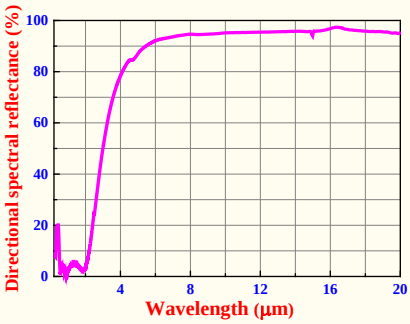


Microstructure



Nanocrystalline nature



Spectral selectivity behavior

Preamble. The direct method of harnessing solar energy is the solar thermal conversion using solar collectors. These collectors use spectrally selective absorber surface which has high absorptance (α) in the solar spectrum region (0.3-2.5 μm) and low thermal emittance (ε) in the infrared spectrum region (2.5-30 μm). For solar thermal power generation, high-temperature absorber coatings are used in concentrating solar power (CSP) systems. In addition to high absorptance, for CSP applications, low thermal emittance is an important property. This is because the thermal re-radiative losses of the absorbers increase proportionally by T^4. In order to increase the efficiency of the solar thermal power plants, solar selective coatings with high spectral selectivity (α/ε) and high thermal stability are necessary.

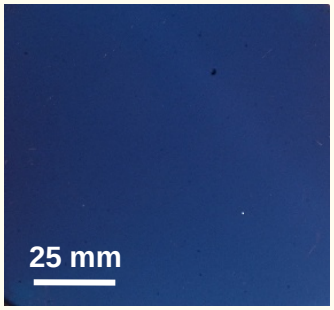
Current Level of Technology. In order to develop manufacturing capabilities of receiver tubes and other CSP technologies, CSIR-NAL has developed several high-temperature spectrally selective absorber coatings on coupon level samples (up to 150×150 mm^2) using sputtering processes. These coatings exhibit $\alpha > 0.950$ and $\varepsilon < 0.07$ on stainless steel substrates and are stable in vacuum for 1000 h at 600°C and in air for 1000 h at 350°C under cyclic heating conditions. The know-how for development of technology for commercial production of the absorber coatings is available with CSIR-NAL.

Design and Properties of Spectrally Selective High-Temperature Absorber Coatings

Coating Type	α	$\varepsilon_{82°C}$*	Stability (Temperature / Time)	
			Air	Vacuum
$TiAlN/TiAlON/Si_3N_4$ (*USP/07,585,568, Indian Patent /257392*)	0.950	0.07	600°C / 2 h	-
AlTiN/AlTiON/AlTiO (*PCT/IN2012/000451, PCT/IN2013/000549*)	0.955	0.08	-	600°C / 100 h
TiAlSiN/TiAlSiN/TiAlSiON/TiAlSiO (*PCT/0182NF2013*)	0.954	0.07	350°C / 1000 h	600°C / 1000 h
TiAlC/TiAlCN/TiAlSiCN/TiAlSiCO/TiAlSiO	0.961	0.07	325°C / 300 h	600°C / 100 h

*****Stainless steel substrate*

Solar selective absorber coatings on stainless steel substrates

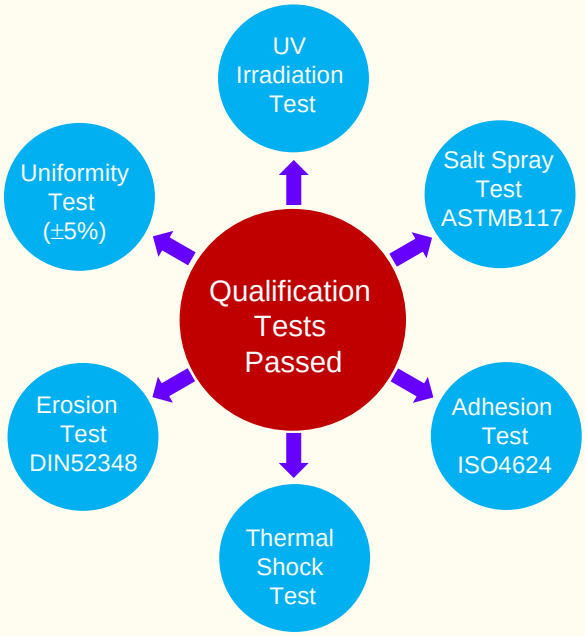


Flat

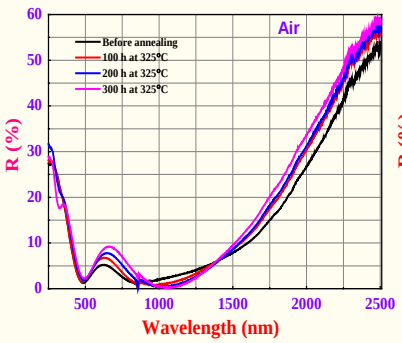
Cylindrical

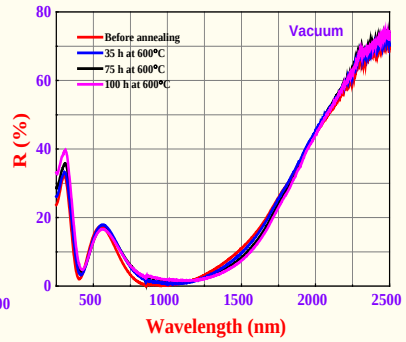
Salient Features of Coating Technology

- Uses nitrides, oxy-nitrides, oxides and carbides, which are thermally and mechanically stable
- Exhibits compositional stability
- Uses tandem absorber concept to enhance the selectivity
- Coating design based on gradient refractive indices
- Nanometric scale tandem absorber
- Exhibits high absorptance (>0.950) and low emittance (<0.07) on SS
- Uses environmental friendly process

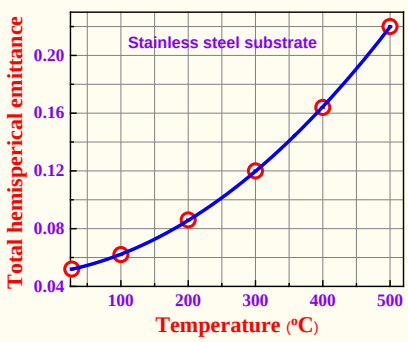


Cyclic Heating Performance



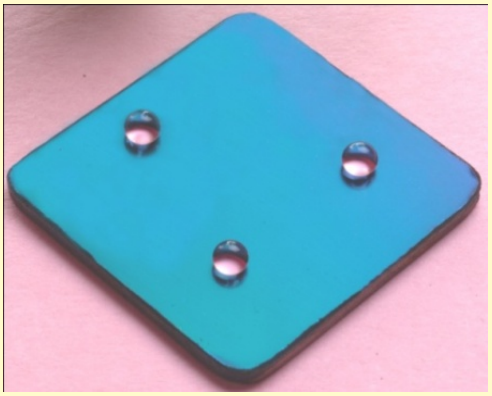


High Temperature Emissivity



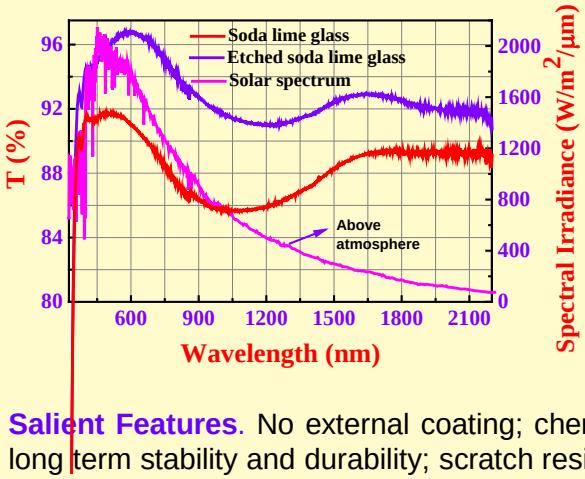
Know-How for Related Technologies

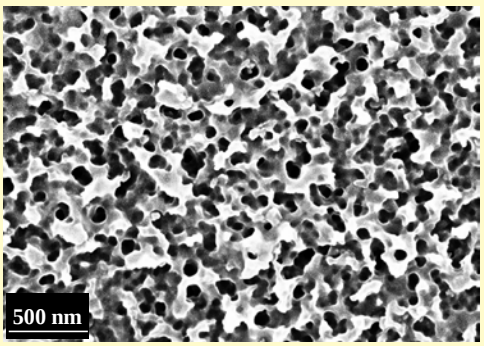
Self cleaning ZnO coatings with broadband anti-reflection properties



Salient Features. Water contact angle >150°; sliding angle <5°; front surface reflectance <4%; thermal stability up to 450°C; broadband anti-reflection characteristics

Chemically etched nanoporous soda lime glass with broadband anti-reflection property





Salient Features. No external coating; chemically stable in most of acids and alkalis; long term stability and durability; scratch resistant; superior mechanical properties, high uniformity; broadband anti-reflection characteristics; easy to scale up

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