Optical multilayer for thermal energy conversion

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Control of emissivity in optical multilayer is of fundamental importance to optimize thermal conversion efficiency of high vacuum flat solar thermal panels. Results obtained on Chromium Oxide based multilayer will be presented and discussed.

Keywords: emissivity, conversion efficiency

1. Introduction

The new developed high vacuum flat solar thermal panel [1] has moved the operating temperature of flat collector from 60°C up to 200°C. Under high vacuum at such temperature the main heat dissipation is due to optical and radiative losses. Therefore, a key component of high vacuum flat solar thermal panel is the Selective Solar Absorber (SSA). SSA should absorb the solar radiation and it should not emit the thermal radiation. The optimal transition wavelength from high absorbance to high reflectance depends on the absorber working temperature [2] and it has been investigated (see fig.1).

The radiative properties of commercial absorber have not yet been optimized for the new working temperature. In this work we present optical simulations of selective solar absorber. From the emissivity curve the spectrally averaged emissivity is calculated and the energy conversion efficiency estimated.

2. Results

The simulations indicate that the cut-off wavelength can be easy changed adjusting the layer thickness and that an overall efficiencies higher than 50% can be obtained at temperature up to 250°C.

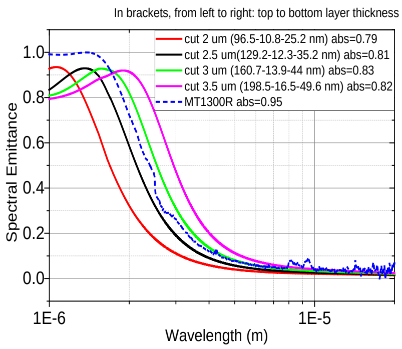

Fig. 1 Spectral emissivity of multilayer selective absorbers optimized for different cut-off wavelength (2.0, 2.5, 3.0, 3.5 μm solid lines), compared to a commercial absorber for low temperature applications (blue dotted line).

Also the stagnation temperature can be increased by more than 100°C.

The optical multilayers based on chromium oxide have been deposited by DC magnetron sputtering on aluminium and copper substrate. Optical properties are measured by ellipsometry. Reflectivity is measured by integrating sphere and OSA in visible and near IR and by FTIR in the mid and far IR. The thermal efficiency was measured using custom instrument, Mini Test Box (MTB) developed to measure the abosorber performance in high vacuum [3,4].

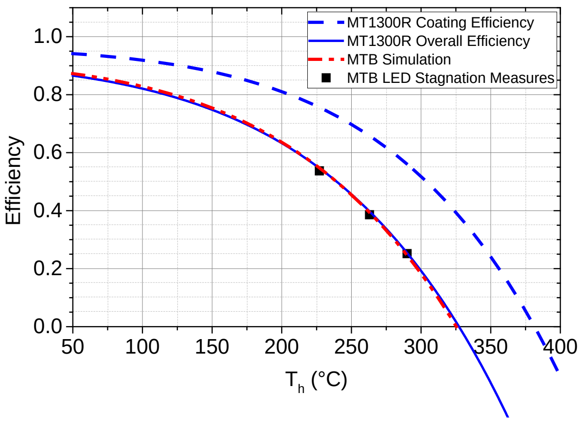

Fig. 2 Efficiency versus Absorber temperature T_h: Mini-test-box(MTB) simulated efficiency (red, dash dot), Led Measured MTB efficiency (black squares), Commercial absorber overall efficiency (blue solid line) and commercial coating efficiency (without taking it to account substrate radiative losses) blue dashed line.

References

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