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IN-SITU EMISSIVITY ASSESSMENT OF GRADE 5 TITANIUM IN HIGH-ENTHALPY FLOWS FOR CATALYSIS INVESTIGATIONS

Abstract

This work investigates the spectral emissivity assessment of grade 5 titanium (Ti-6Al-4V) in high-enthalpy flows. Material samples are examined in plasma wind tunnel (PWT) experiments under conditions relevant for atmospheric entry. Especially the assessment and identification of catalytic recombination processes require precise knowledge of the thermal state and heat flux balance on the material surface. In past studies at the Institute of Space Systems (IRS), the determination of the emissivity was identified as a major contributor to heat flux uncertainties. Therefore, the feasibility of accuracy improvements for the spectral emittance determination using near-infrared and mid-infrared spectrometers is investigated.

Exposition to high-enthalpy dissociated gas flows causes physical and chemical alterations of material surfaces which includes variations of the spectral emissivity. In past studies, the emissivity determination of material samples was often carried out before and after PWT tests to take these alterations due to oxidation, erosion and melting into account. A dedicated emissivity measurement facility (EMF) with a variable black body environment is used for this purpose. However, such results may only represent a coarse approximation of the effective properties of a surface that is actively interacting with an oxidizing high-enthalpy gas environment, which could not be replicated in the EMF. This motivates the investigation of dynamic surface transformations and its influence on the spectral emissivity in the infrared spectrum with time-resolved spectrometric in-situ measurements during PWT experiments.

The plasma wind tunnel PWK3 used for heterogeneous catalysis investigations at IRS is equipped with an inductively coupled plasma source. The electrodeless design allows for the creation of pure oxygen plasmas without contamination with further working gases or eroded electrode particles.

During PWT testing, the temperature of a material sample can be determined by monitoring the back surface of the sample with a miniature pyrometer. Using a near-infrared spectrometer and a mid-infrared Fourier-transform spectrometer with a combined wavelength range of 1 m to 12 m, more than 90

The comparison of spectrometric in-situ and EMF measurement results allows for a quantification of surface emissivity uncertainties of past and future PWT experiments for heterogeneous catalysis investigations and thereby improving the determination of catalytic recombination coefficients.