R E P O R T

Infrared-Optical Characterization of 4 Samples

commissioned by

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R E P O R T

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1 Aim of the Investigation

The aim of the investigation is the determination of the solar absorbance and the thermal emittance of 4 samples. The sample descriptions are is given in Tab. 1.

Tab. 1: Sample numbers and description of the 4 samples

sample number	description
1	TUP 721243 T4 HR
2	TUP 721233 T4
3	TYP 721270 T4 HR
4	TYP 721220 T4

2 Theoretical Background

2.1 Determining the spectral reflectance R_{dh}

First, the spectral directional-hemispherical reflectance R_{dh} of the samples was measured at ambient temperature by an integrating sphere (Fig. 1). The spectral absorbance α_λ can be calculated from the spectral directional-hemispherical reflectance R_{dh}:

$$\alpha_\lambda = 1 - R_{dh} \quad . \tag{1}$$

According to Kirchhoff's law, the spectral absorbance α_λ equals the spectral emittance ε_λ.

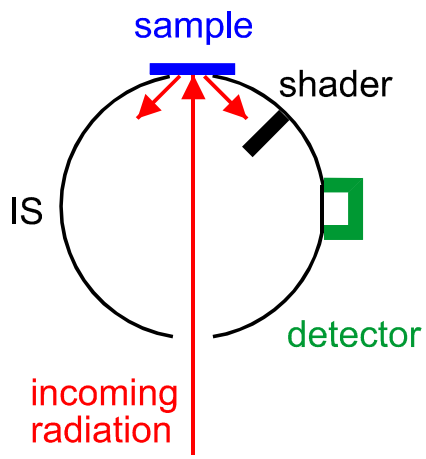

Fig. 1: Measurement of the directional-hemispherical reflectance R_{dh} with an integrating sphere.

The samples were measured with one FTIR-spectrometer from Bruker in the wavelength range between 1.4 µm and 35 µm. The thermal emittance $\varepsilon(T)$ was then derived from the spectral emittance ε_λ as described in Chapter 2.2.

The wavelength range between 0.25 µm and 2.5 µm is covered by a diffraction spectrometer from Perkin Elmer. The solar absorbance α_{solar} was derived from the spectral absorbance α_λ as described in Chapter 2.3.

2.2 Determining the thermal emittance $\varepsilon(T)$

The thermal or infrared emittance $\varepsilon(T)$ gives the amount of thermal radiation that is absorbed by the surface. The thermal emittance $\varepsilon(T)$ with respect to the temperature T can be calculated by integrating the spectral emittance ε_λ over all wavelengths with the Planck-function $i_\lambda(T)$ as a weight function:

$$\varepsilon(T) = \frac{\int_{1.4}^{35} \varepsilon_\lambda(T) \cdot i_\lambda(T) \cdot \mathrm{d}\lambda}{\int_{1.4}^{35} i_\lambda(T) \cdot \mathrm{d}\lambda} \quad . \tag{2}$$

The Planck-function $i_\lambda(T)$ gives the intensity emitted by a black body at a certain temperature T. At room temperature, the wavelength range between 1.4 µm and 35 µm is significant.

2.3 Determining the solar absorbance α_{solar}

The solar absorbance α_{solar} is calculated by integrating the spectral absorbance α_λ over all wavelengths with the solar radiation onto the soil s_λ as weight function:

$$\alpha_{solar} = \frac{\int_{0.3}^{2.5} \alpha_\lambda \cdot s_\lambda \cdot \mathrm{d}\lambda}{\int_{0.3}^{2.5} s_\lambda \cdot \mathrm{d}\lambda} \quad . \tag{3}$$

The calculations are done in accordance with DIN EN 410.

3 Results

The samples were measured at different positions in order to test their homogeneity. The reflectance at different positions is quite the same.

The spectral emittance ε_λ of the investigated samples is depicted in Fig. 2 as a function of the wavelength. The resulting thermal emittance $\varepsilon(T)$ of the samples is shown in Fig. 3 as a function of the temperature.

The solar absorbance α_{solar} as well as the thermal emittance $\varepsilon(T)$ at a temperature of 10 °C is given in Tab. 2.

Tab. 2: Solar absorbance α_{solar} and thermal emittance $\varepsilon(T)$ of the samples.

Sample description	**solar absorbance** α_{solar}	**thermal emittance** $\varepsilon(T)$ **bei** T **= 10 °C**
TUP 721243 T4 HR	0.80 ± 0.02	0.88 ± 0.03
TUP 721233 T4	0.94 ± 0.02	0.94 ± 0.03
TYP 721270 T4 HR	0.72 ± 0.02	0.88 ± 0.03
TYP 721220 T4	0.84 ± 0.02	0.95 ± 0.03

Würzburg, 11 June, 2008

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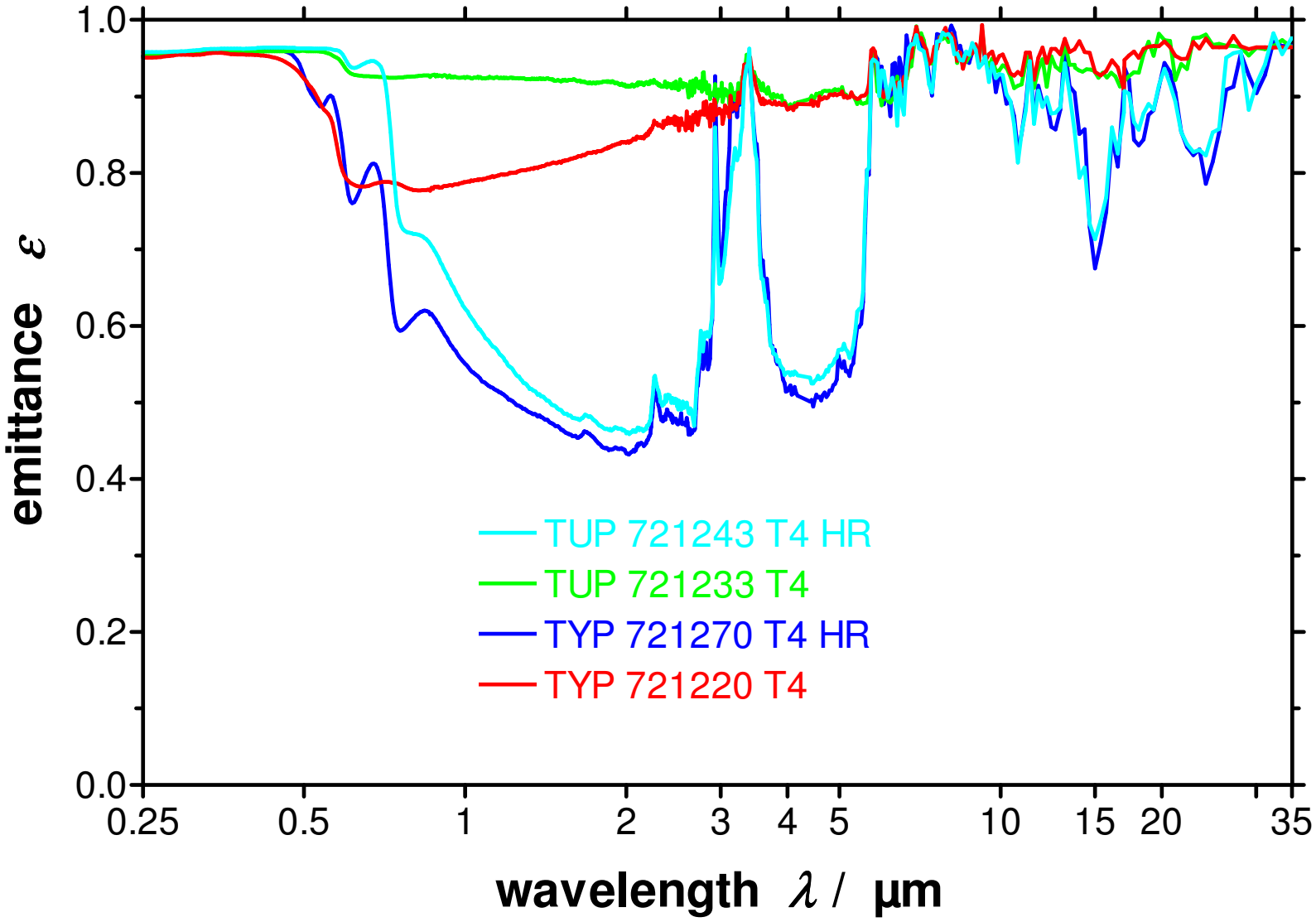

Fig. 2: Spectral emittance ε_λ of the samples in the wavelength range between 0.25 µm and 35 µm.

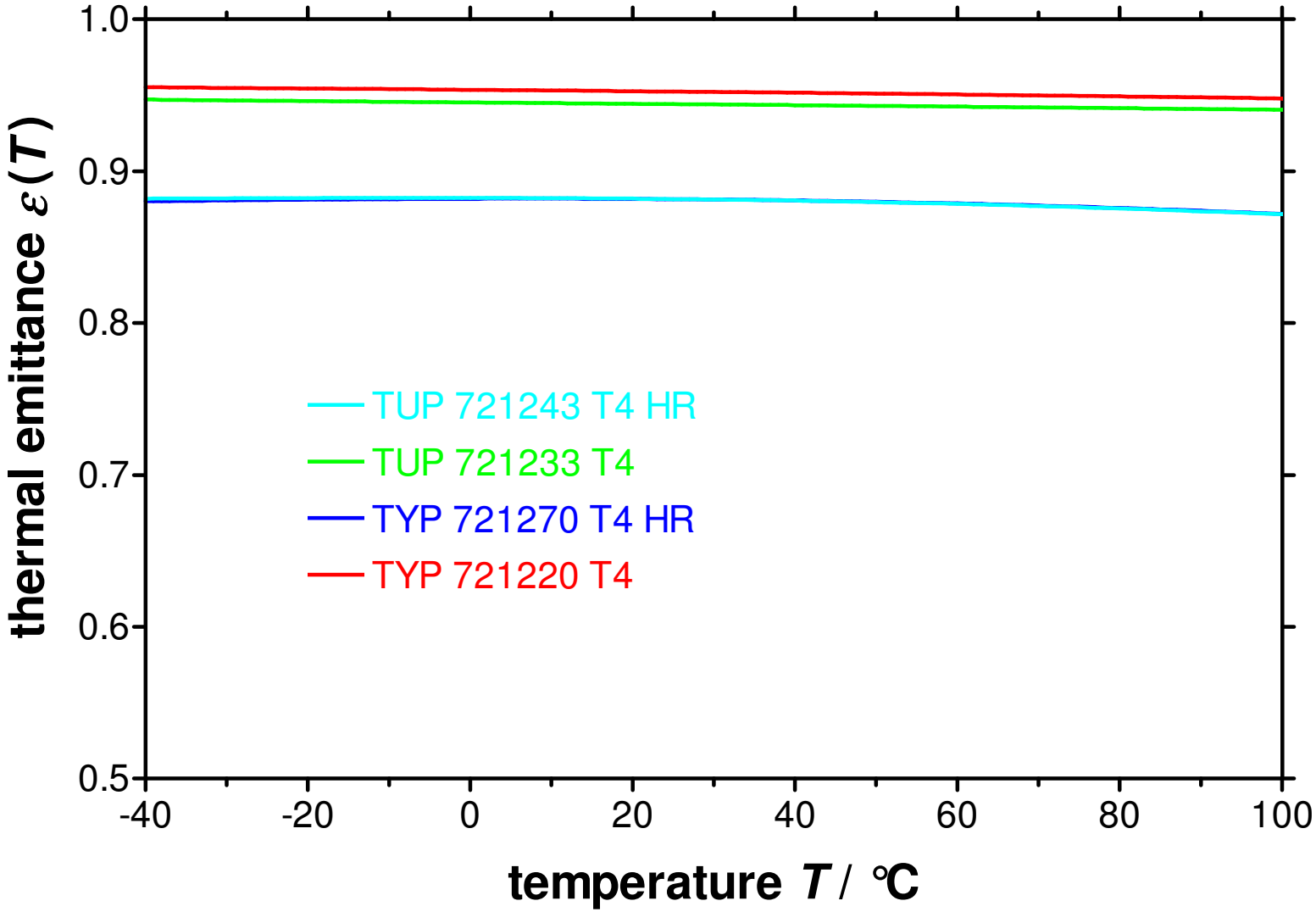

Fig. 3: Thermal emittance $\varepsilon(T)$ of the samples in the temperature range between -40 °C and +100 °C.