Optical and thermal Evaluation of transparent Materials and Surfaces by FTIR and integrating Spheres.

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Abstract

Integrating sphere measurements are shown in the wavelength range from 0.35μm up to 18μm. The spheres are coupled to a rapid scan FTIR Bruker IFS66. The design of the sphere allows to determine spectral normal hemispherical as well as spectral normal diffuse reflectance and transmittance values. The excellent resolution and reproducibility is demonstrated by noise spectra and some measurements. The easy sample handling makes this instrument to a versatile tool for the development of new materials as well as ageing investigations.

Introduction

Many Solar Energy Laboratories throughout the world uses various sperctrophotometers to evaluate the Optical and thermal behaviour of materials used in the field of solar energy and many other areas.
The accurate and reproducible determination of the spectral near normal hemispherical reflectance or normal hemispherical transmittance in the UV-VIS-IR-range is of great importance for the design and evaluation of new materials as well as for ageing studies of materials for the conversion of solar radiation.
In order to have the same geometrical arrangement for the whole spectral range from 0.35μm up to 18μm two integrating sphere with different coatings are coupled to the FTIR instrument.

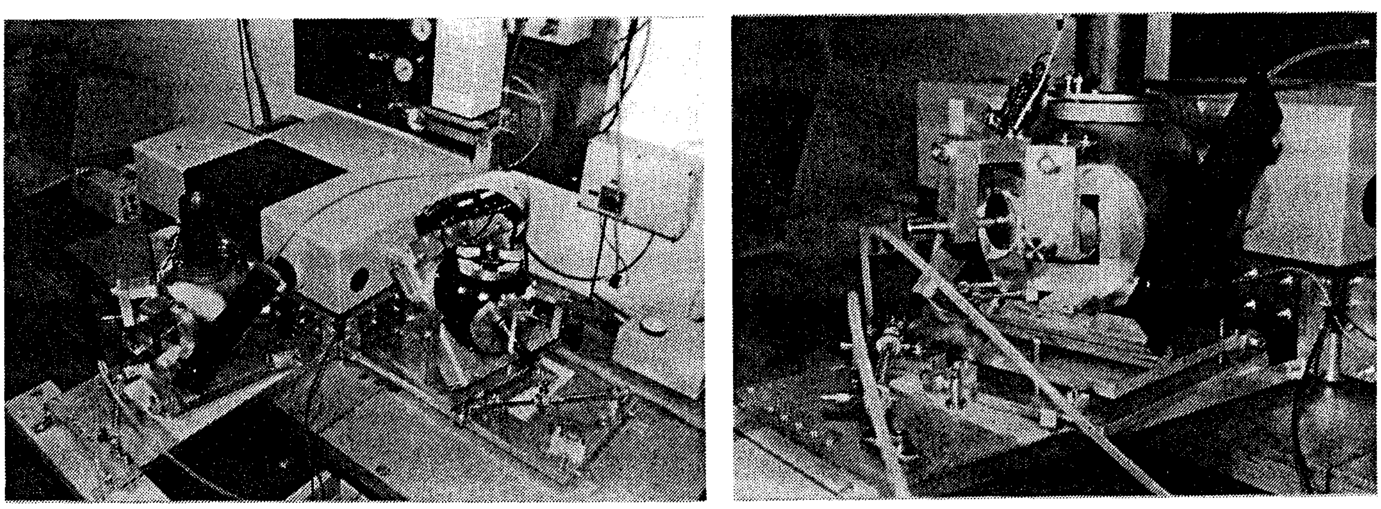

Fig. 1. The Spectrometer with the attached Spheres

The rapid scan FTIR spectrometer

The heart of the used FTIR-instrument is a laser controlled high precision air bearing interferometer. The simple Optical setup leads to a very high energy throughput. The wavelength range is from 0.35 up to about 18μm, using 3 sources, 2 beamsplitters and 5 detectors. The resolution of the instrument is better than 0.25 cm^{-1}; which is, especially in the UV-NIR range, for our purposes, much to high. Typical resolutions used in these wavelength ranges are shown in the noise spectra. To reduce water absorption bands, the instruments and the coupled integrating spheres are purged with dry air.

1. Interferometer
2. Beamsplitter
3. Glowbar
4. Tungsten halogen
5. Xenon
6. MIR-Sphere
7. UV-NIR-Sphere

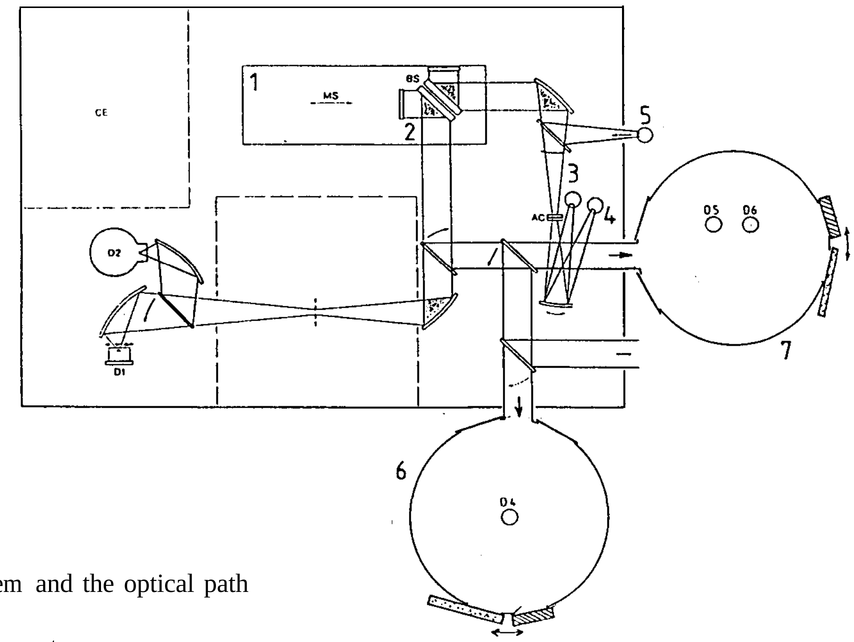

Fig. 2. Scheme of the optical system and the optical path

<u>Table of the measurement arrangements</u>

Source	Beamsplitter	Detector	Integrating sphere	Wavelength range
Glowbar	Ge/KBr	Hg-Cd-Te	Diffuse gold coated integrating sphere	1,5 - 18,0 μm
Tungsten halogen	Si/Quartz	Ge-Photodiode	Barium sulfate coated integrating sphere	0,8 - 1,9 μm
Tungsten halogen	Si/Quartz	Si-Photodiode	Barium sulfate coated integrating sphere	0,35 - 1,0 μm
Xenon	Si/Quartz	Si-Photodiode	Barium Sulfate coated integrating sphere	0,3 - 0,8 μm

<u>Integrating sphere attachment</u>

The integrating spheres have a diameter of 203mm (8") and are fabricated by Labsphere. The UV-NIR sphere is coated with barium sulphate (Spectraflect) and the MIR sphere is coated with a diffusely reflecting gold coating. The coatings of both spheres have neglectible specular reflectance factors in the whole measurement range. For the reflectance measurements the sample and the reference are attached to the sphere simultaneously to avoid errors due to the different reflectances of the sample and the reference. For the determination of the transmittance one port is open and serves as reference and the sample is attached to a second port. In this mode the near normal hemispherical reflectance and the normal hemispherical transmittance are measured. By opening additional ports the directly reflected or transmitted radiation from the sample leaves the sphere and the diffuse reflectance or transmittance can be measured.
The sphere and the field of view of the detectors are designed such, that no baffles are needed inside the sphere.
The spheres are pneumatically driven from the sample to the reference position and vice versa.

<u>Sample handling</u>

For routine measurements, the fast and easy Sample handling is a very important point. The samples can be attached to spheres in fact very simple and for hemispherical measurements no additional adjustments are necessary.

<u>Noise spectra</u>

The noise spectra of 100% lines and their deviation demonstrate the errors of the instrument due to instabilities during the measurement. In addition, they show clearly the usable wavelength range of the chosen combination detector, beamsplitter and source and the magnitude of the expected noise in the samples to be measured.

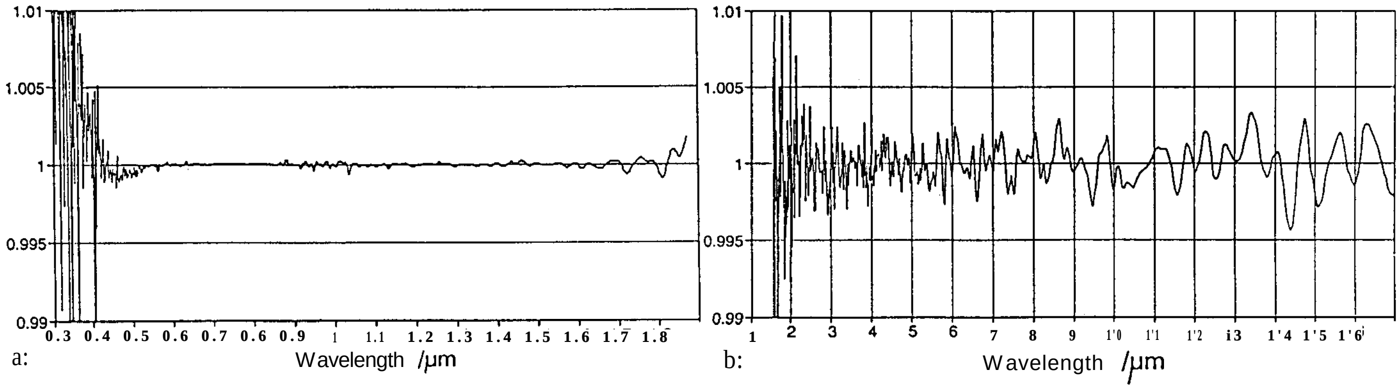

Fig. 3 a: Noise spectra for the UV-NIR sphere measurements (512 scans, resolution: 64 cm^{-1})
b: Noise spectra for the MIR sphere measurements (512 scans, resolution: 8 cm^{-1})

Measurement examnle

As an example the near normal hemispherical reflectance of a selective solar absorber coating is shown:

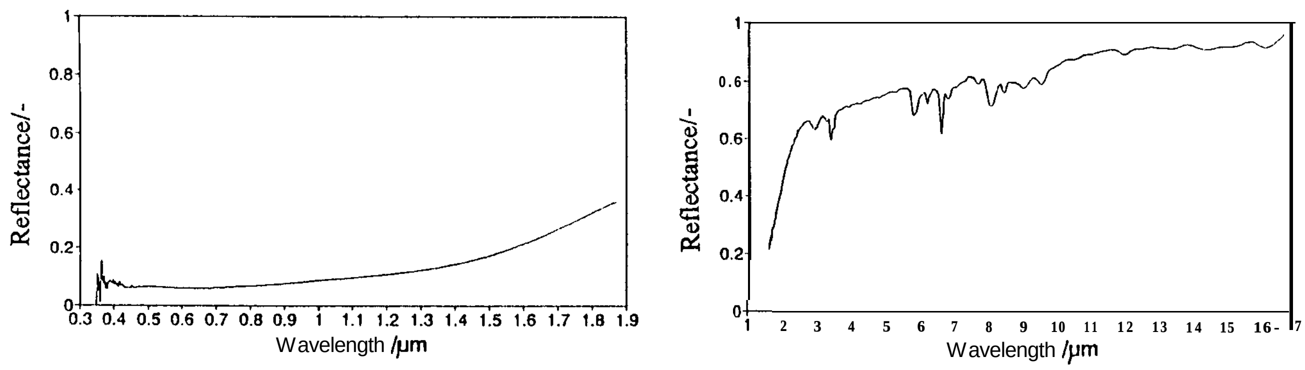

Fig. 4 Near normal hemispherical spectral reflectance of a selective absorber coating

Conclusions

Up to now at least two instruments are needed to determine the spectral reflectance and transmittance in the wavelength range from $0.35\mu m$ up to $18\mu m$. The main advantage of the here presented rapid scan FTIR instrument with the attached integrating spheres is the capability to measure spectral normal hemispherical transmittance and reflectance values in the whole spectral range.
The absolute accuracy of the transmittance measurements can be examined in the noise spectra. In the reflectance mode the absolute accuracy of the results are dependent on the accuracy of the Standard, but this is not a subject of the here presented Paper.
The resolution of the instrument as well as the wavelength accuracy is excellent. The sample handling is easy and for flat samples no additional adjustments are necessary.
Our further efforts will focus on the development of an universal goniometer and an ellipsometer coupled to this FTIR instrument.

Acknowledgements

This work has been financially supported by the "Bundesamt für Energiewirtschaft" BEW, Switzerland and the minister of research and technology, Germany.