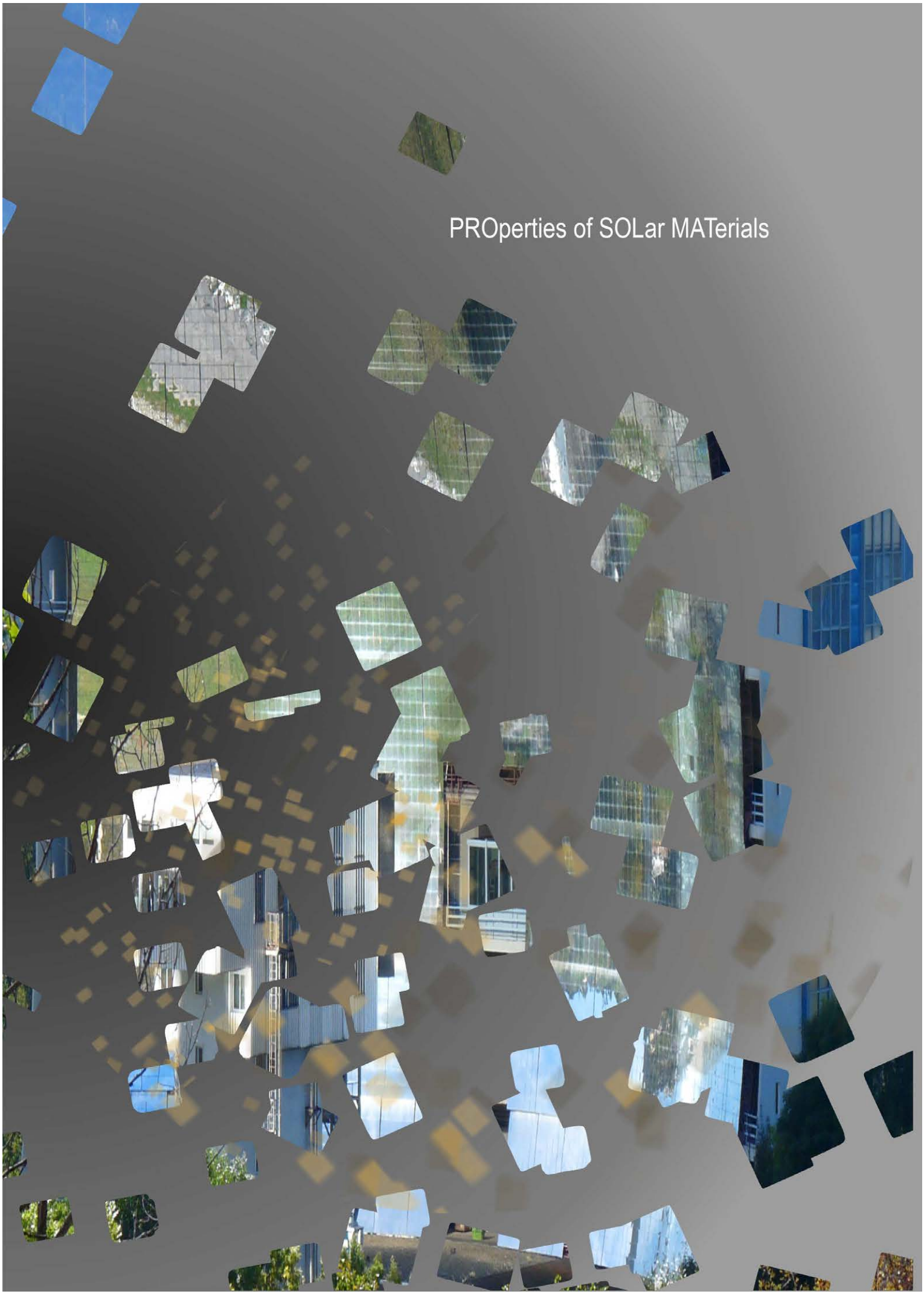
PROperties of SOLar MATerials

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Identity

Composition of the team

Team leader: C. Escape, (IE CNRS)

Keywords
Thermal diffusivity, spectral reflectance and transmittance UV, Visible, IR, Angular, BRDF, calibration.

Topics
Measuring optical and thermal properties
Calibration
Metrology

Contracts
- Equipex SOCRATE

Large equipment
- LFA 457 MicroFlash, 04/2012, EQUIPEX SOCRATE.
- CASI, 10/2013, EQUIPEX SOCRATE.
- SOC 100 HDR, 02/2013, EQUIPEX SOCRATE.
- Lambda 950, 07/2015, EQUIPEX SOCRATE.

Scientific report

INTRODUCTION

The PROMES laboratory has been selected for the EQUIPEX SOCRATE (a state-funded project) with the objective to install several instruments dedicated to the measurement of thermo and thermo-optical properties of various solar materials.

The Thermo-optical properties of the materials are used for modeling the thermal properties for the thermal solar plants. For example, for a voluminous or surface absorber of a solar tower plant or for a tube-shaped receiver of a solar parabolic trough collector or linear Fresnel, the knowledge of solar absorptivity and emissivity is essential. The reflectivity of mirrors and the conductivity of materials used for the thermal tank have to be known to compare their efficiency and find the most economical model to decrease the costs of the solar plant without losing nominal operating efficiency.

The department manages equipments able to measure these optic and thermic properties using a spectral-radiometer UV-Visible, a spectral reflectometer NIR-IR, a bidirectional reflectometer, a thermal diffusivimeter, an optical bench for calibration purpose and a solar furnace instrumented to measure solar reflectivity (DISCO).

1. EQUIPEMENTS

1.1. LFA 457 MicroFlash

This device is dedicated to measure the thermal diffusivity samples from room temperature to 1100°C. The thermal conductivity can then be calculated knowing its specific heat and density. The results obtained are essential in the knowledge of materials for heat storage.

Figure 1 : LFA 457 in PROMES

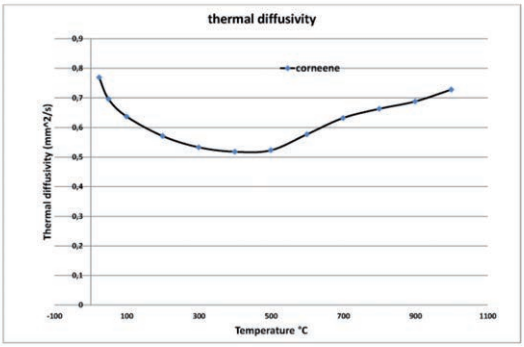

Figure 2 : Thermal diffusivity of Cornéenne sample

1.2. SMS CASI scatterometer

This device is dedicated to measure angle scattered by a reflected ray. The measure is done by a 633nm laser. The laser shoots the sample, itself placed on a turning precision rotator (ϕ), while the detector turns around the sample to measure the scattered angles. In this way the device allows us to know the BRDF (Bidirectional Reflectance Distribution Function) or the BTDF (Bidirectional Transmittance Distribution Function) of the sample. In another mode we can characterize the sample's roughness.

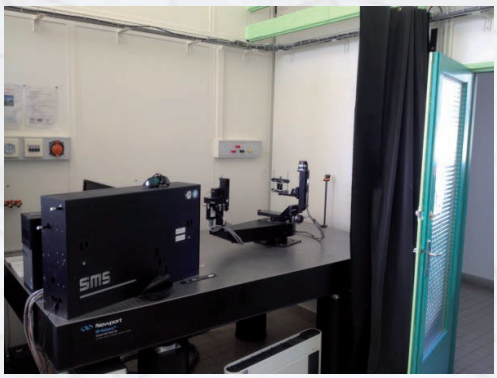

Figure 3 : CASI in PROMES

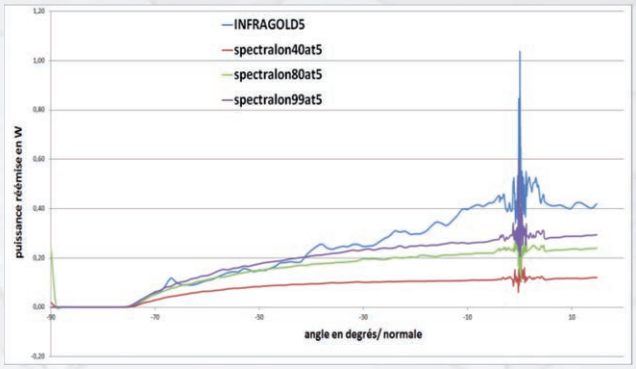

Figure 4 : BRDF measured on PROMATSOL's standards

1.3. SOC 100HDR

The SOC-100 Hemispherical Directional Reflectometer provides a unique capability for characterizing and exploiting the optical properties of materials. Coupled to the Nicolet FTIR, this device provides polarized, angular diffuse reflectance measurements for 10° to 80° incident angles, for the 2.0 to 25.0 µm spectral region from. In addition our device is equipped with a heater able to heat the sample up to 500°C for the reflectance measurement.

Figure 5 :SOC100HDR in PROMES

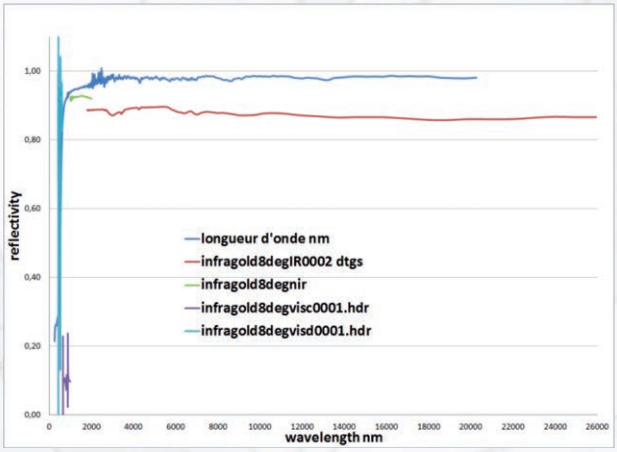

Figure 6 : Hemispheric Reflectivity of a standard compared to its measurement with the SOC100HDR

1.4. Perkin Elmer Lambda 950

Our spectrophotometer Uv/Vis Lambda 950 (Perkin Elmer) is fitted with two accessories allowing us to measure reflectivity and transmissivity normal hemispheric (8° with integrating sphere) and angular with the TAMS accessory (Total Absolute Measurement System) for a range from 250nm to 2500nm:

- specular and diffuse reflectivity;
- specular and diffuse angular reflectivity;
- direct normal transmitivity with variable incident angle.

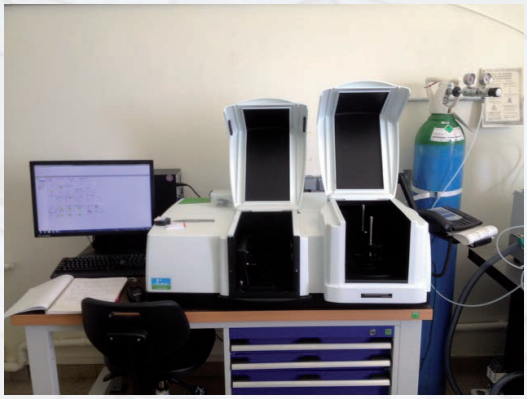

Figure 7 : Lambda 950 fitted with the TAMS accessory

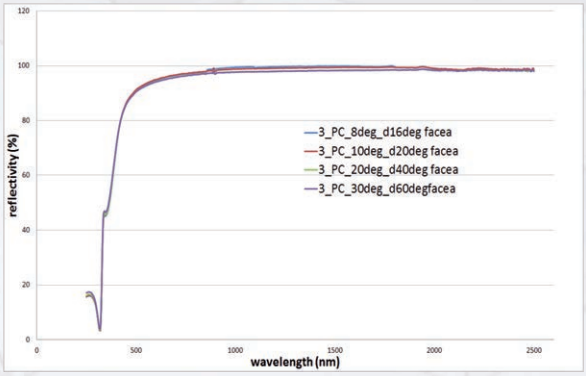

Figure 8 : Reflectivity of « miroir_3PC » face A, face B with and without specular component

1.5. DISCO

DISCO is a solar reflectometer that enables the measurement of the solar directional reflectivity of a sample illuminated with concentrated solar radiation. The sample can be heated with a 2m diameter solar parabola.

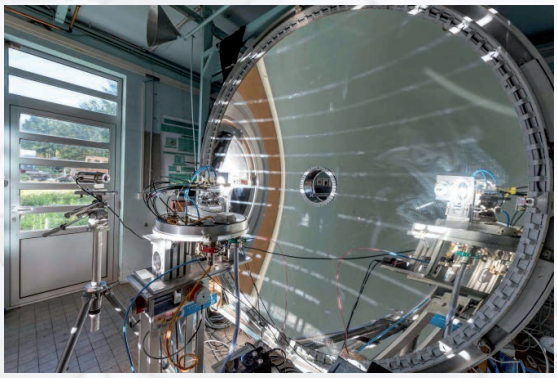

Figure 9 : DISCO equipment

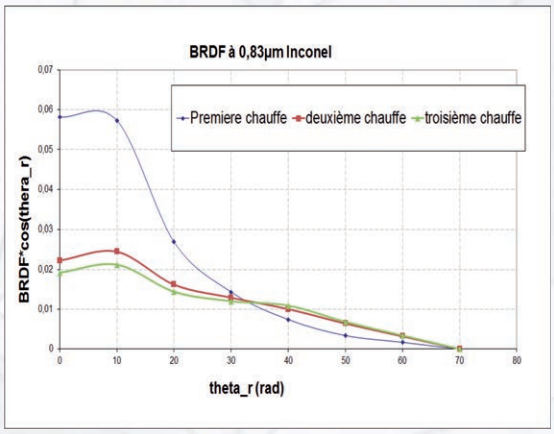

Figure 10 : Measurement of Inconel at 400°C

1.6. Pyrometric calibration bench

The department maintains upgrades and proposes to users a calibration bench for temperatures ranging from 250°C to 2500°C with 3 regulated blackbodies and 2 calibrated pyrometers for the control.

This bench is fitted with customizable tables that can receive various user's devices.

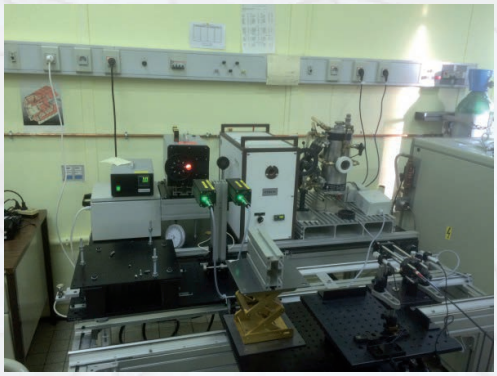

Figure 11 : Pyrometric calibration bench

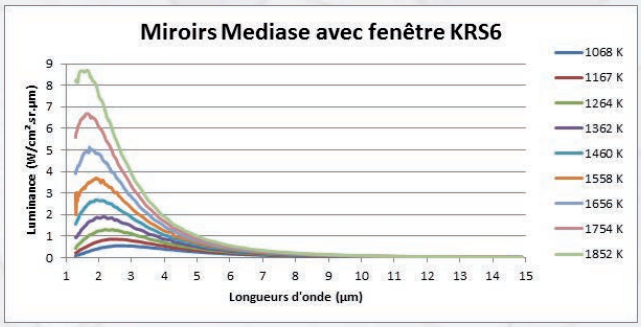

Figure 12 : Measurements on blackbodies

2. METROLOGY

2.1. Calibration and servicing

In order to provide reliable measurements, the department is equipped with calibrated standards of reflectance that cover the spectral ranges of the devices owned by the department. In operation, we use « service standards » that are linked with the reference standards calibrated by certified laboratories. The devices are checked in local by these standards and the manufacturers or providers. Furthermore the servicing is done with the contribution of the manufacturers.

2.2. Functioning

The department works on service or on training as the number or the specificity of the experiment needs.
Current protocols are available, and the department can also provide and operate specific techniques to meet the objectives and specification of the users. For instance the department can develop specific sample holders in collaboration with the STAR department or develop protocols following the literature or the manufacturers.
The customer can be trained to the use of any device in order to be standalone.

2.3. Records

The department has a tracking system for the data and the measurement procedure.

3. PROSPECTS

3.1. Pyroreflectomtry

The department can provide 2 devices dedicated to measure temperatures without contact by pyroreflectometry. The goal is to maintain and implement this knowledge.

3.2. DISCO

Christophe Escape is able to manage the DISCO experiment in its basic configuration. The next challenge is to connect a spectrophotometer to DISCO to measure the spectral information

3.3. Round-robin tests

In order to enhance reliability of the measurements and to increase networking networks, we are developing collaborations with the Mines Albi Graduate school of Engineering. In 2016 participation to round-robin tests is planned.