LUMI-SMART project

Postdoc position at CentraleSupelec, Université Paris-Saclay

Synthesis of new efficient thermo-luminophore materials for temperature measurement in combustion.

Scientific project:

Surface temperature knowledge is fundamental in energy converting systems and transfer processes such as turbines, rocket engines, nuclear reactors, or even glass melting furnaces. Their efficiencies and lifetime are strongly dependent of the wall temperatures which require accurate and highly resolved information.

Laser induced phosphorescence technique allows to measure these temperatures using rare-earth or transition metal doped ceramic materials, so-called thermo-luminophore.

Under laser irradiation the deposed phosphor on the interest surface emits a signal. This property is temperature-dependent and exploited to determine it. Concretely, the phosphorescence signals are shown to evolved temporally and spectrally with temperature, allowing to obtain a precise evaluation of the temperature through a preliminary calibration, since the phenomenon is measured using specially design optical probe. This technique displays many benefits since it is no invasive comparing to the traditional techniques (thermocouples, …) and allows a very high temporal and spatial resolution of temperature in the practical system. The current thermographic phosphors show a limited operation temperature-range and often cannot be used for temperatures higher than 1600K. They can also be affected by atmosphere composition.

To overcome these user constraints, two laboratories EM2C and SPMS have thus joint their expertise respectively in combustion systems such as high pressure oxy-combustion chamber and in synthesis and characterization of pioneering materials to develop and finely characterized new temperature sensitive thermo-luminophore.

This expected future material will be finally used in subscale hydrogen-fueled rocket engine in which temperatures move from cryogenic temperature (20 K) to 2000 K. To this end a specific experiment has been conjointly designed that allows identifying the response of thermographic phosphors as a function of temperature, incident radiative flux, chemical environment and pressure.

Objectives

1) Extend and improve the Full Spectrum Fitting method to pressure and chemical environment, a calibrated method recently [1, 2] develop by EM2C team to retrieve the temperature independently of the incident radiative flux.
2) Synthesize and characterize new thermo-luminophore for combustion application. In particular, commercial materials as well as newly formulated and synthesized thermos-luminophores will be characterized precisely as a function of temperature and surrounding atmosphere.
3) Applied the new thermo-luminophore in a real combustion chamber at high pressure.

Academic Requirements

A PhD in the fields of material synthesis and characterization or in applied physics (spectroscopy techniques, etc) is required.

Additional knowledge in the field of data process and statistical analysis will be beneficial.

Funding: Labex LaSIPS

Contract duration: 12 months

Team

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References

[1] V. Lechner, C. Betrancourt, C. Mirat, P. Scouflaire, S. Ducruix, Full Spectrum Fitting method: a new approach for instantaneous phosphor thermometry in harsh environments, Experiments in Fluids, 2021, accepted
[2] V. Lechner, C. Betrancourt, P. Scouflaire, L. Vingert, S. Ducruix, Dynamic characterization of wall temperature in LOX/CH4 rocket engine operating conditions using phosphor thermometry, Proceeding of the Combustion Institute, accepted