PhD (CIFRE) topic proposal for the period 2021-2024

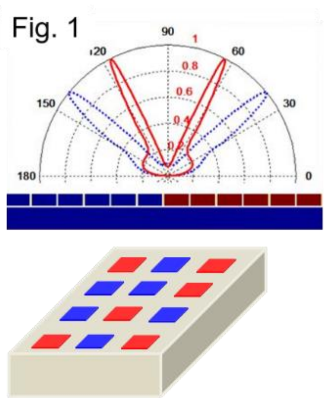
Subject: Thermochromic nanophotonics for emissivity control

Nanophotonics allows shaping the optical properties of materials in a broad spectral range, from the UV to the THz band. It is a major research field addressing a wide range of applications. In particular, emissivity engineering using nanostructures is showing great potential for thermal management, energy harvesting and safety [1].

Following a successful collaboration on the topic of near-field heat transfer [2], the academic and industrial research laboratories Laboratoire Charles Fabry (CNRS/IOGS) and Thales Research & Technology are joining forces to deliver nanophotonics-engineered coatings with unprecedented emissivity properties. Specifically, we will design, fabricate and characterize coatings made up of photonic crystals and metamaterials whose emissivities can be controlled dynamically in order to reach functionalities such as passive thermal regulation or infrared camouflage (Fig. 1). To do so, we will rely on a popular thermochromic material on which LCF and TRT have a long expertise [2, 3]: vanadium dioxide (VO_2).

VO_2 is a correlated oxide with reversible metal-insulator transition at temperature $T_c \approx 68$°C. By heating the material from room temperature, the optical properties change drastically across the transition, especially in the infrared range (Fig. 2). First proofs of principle of VO_2 metamaterial-based coatings for passive thermal regulation and infrared camouflage have been reported [4, 5]. Our objective is to go one-step further by reaching better figures of merit compatible with real-life applications. For this purpose, we will explore new paths in both numerical design and device fabrication, namely: emissivity angular engineering and state-of-the-art thin film deposition techniques (based on ALD technic).

We are seeking for motivated, curious and proactive candidates who are willing to join us on this exciting topic. The PhD student will have the opportunity to work in a very rich interdisciplinary environment and to be involved in collaborative projects (ANR). S.he will benefit from the combined expertise in micro and nanotechnologies and theoretical radiative heat transfer of TRT and LCF. The student will have free access to up-to-date cleanroom and characterization laboratories, as well as advanced computational electrodynamics codes and softwares. S.he will develop skills in numerical design and modelling, thin film deposition, nanofabrication and advanced characterization. A strong interest in both experimental and numerical physics is a prerequisite. Studies in physics or materials science are mandatory.



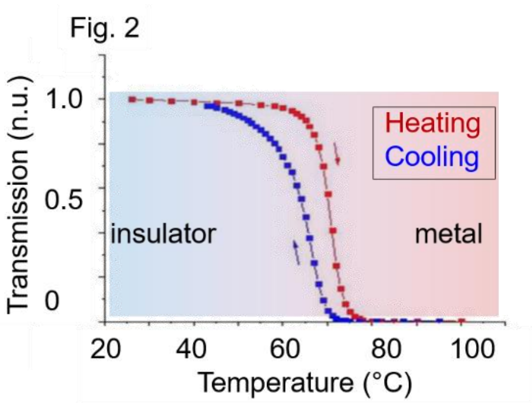


Fig. 1: Illustration of a metasurface with tunable emissivity pattern. The two states (blue and red) can be switched back and forth by controlling the individual metasurface elements.

Fig. 2: IR transmission (4 µm wavelength) of a VO_2 thin film with varying temperature.

Contact:

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References :

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[4] K. Sun et al., ACS Photonics 5, 2280 (2018)
[5] S. Chandra et al., ACS Photonics 5, 4513 (2018)