Please use the following format for <u>the title of the file</u> so as to ease the management of the web site.

ECXX_LABYY_ NOMChercheur_ Numer
ECXX = ECLi, ECL, ECM, ECN, CS
LABYY = acronyme du laboratoire
NOMChercheur = nom du chercheur émetteur du sujet
Numer = numéro de la proposition (01, 02, ….) pour le chercheur

PhD Proposal 2017

School: Ecole Centrale de Lyon	
Laboratory: INL	**Web site: http://inl.cnrs.fr/**
Team: Nanophotonics	**Head of the team: Xavier Letartre**
Supervisor: Ségolène Callard **Co-supervisor: Ali Belarouci**	**Email: segolene.callard@ec-lyon.fr** **Email: ali.belarouci@ec-lyon.fr**
Collaboration with other partner during this PhD: **In France: Institut d'Optique, INSA Lyon**	**In China:**

Title: Dynamic Radiative Heat Transfer at the Nanoscale
Scientific field: thermophotonic
Key words: thermal metasurfaces, functional materials, nanophotonics, near-field transfer, nanofabrication, instrumentation….

Details for the subject:
(Maximal length of 2 pages, including images, list of reference, …The pdf file should not exceed 1Mo)
Background, Context:

Over 60% of energy used in industry is lost as low grade waste heat. Thermal flow management has therefore become a very important challenge due to the limited energy resources and global warming issues. Harvesting, storing, transporting and converting this energy is today a challenging problem. As one of the two fundamental modes of heat transfer, thermal radiation plays an important role in many engineering applications or instruments, such as combustion, heat management of space crafts, nonintrusive temperature measurement, high temperature heat exchangers, and waste heat harvesting. In this context, radiative heat transfer at the nanoscale is of considerable interest due to its promise for important applications in green technology, nanoscience and nanotechnology, and high resolution imaging. Although radiative heat transfer at macroscopic distances is well understood and is set by the Stefan-Boltzmann law for black bodies, radiative heat transfer at the nanoscale remains largely unexplored. When two objects are brought in closer proximity, the thermal radiation is dominated by interference effects and, more importantly, by the near field emerging from the materials surfaces in the form of evanescent waves. Scientists have predicted that near-field thermal radiation can achieve a heat flux exceeding by several orders of magnitude that foreseen by the Stefan-Boltzmann law, which is the conventional limit set forth by Planck's blackbody radiation theory. This holds the promise of dramatic improvements and new capabilities for micro- and nanoscale devices to efficiently generate energy or to enhance data storage in heat-assisted, magnetic recording, to name two applications.

Presently, one of the central research lines in the field is the search for materials where the near-field radiative heat transfer enhancement can be further increased, actively controlled or modulated. With the advances of nanofabrication and characterization techniques in the last decade, researchers start to go beyond conventional bulk materials for the pursuit of tunable radiative properties to meet different needs. In particular, metasurfaces, artificial nanostructures, have attracted much attention recently due to their exotic optical, electric, and thermal properties.

In this highly innovative project, we propose to investigate the design, fabrication and characterization of advanced functional thermal metasurfaces to drive near-field heat exchange between hot and cold surfaces. The project will use dissimilar materials with externally variable optical properties. The study of the radiative properties at high temperatures of these nano-objects and how they can affect near-field radiative transfer will enable a deeper understanding of photon-matter interactions and will lay the foundation for future pioneering devices with an unprecedented level of functionality. Both theoretical and experimental advances are expected to result from this project. The student working on this project will gain knowledge in the fundamental theory of thermal radiation, nanophotonics as well as experience in micro/nanofabrication and thermal/optical instrumentation.

Research subject, work plan:

This position is based on a multidisciplinary environment at the interface of material sciences (semiconductors, dielectric, metals, surface analysis), fundamental physics (heat transfer at the nanoscale, many body physics), mechanical engineering (micro/nanofabrication), and electrical engineering (modeling and design, electrical characterization). It is application oriented, yet contains a strong content of fundamental science. The student will contribute to the design of thermal metasurfaces with advanced functionality able to guide, focus and split near-field heat fluxes. This will be done in close partnership with the Charles fabry laboratory at Institut d'Optique (Palaiseau, France). The candidate will then fabricate the micro-nano-engineered surfaces in the cleanroom facilities of NANOLYON (Lyon Institute of Nanotechnology). Both spectral and directional radiative properties will then be investigated and active tuning in the far-field demonstrated. Finally, she/he will validate experimentally the active control of near-field heat transport enabled by these functional thermal metasurfaces.

We are seeking creative and highly motivated students with strong research interests to pursue a Ph.D. degree in the area of nanoscale optics, heat transfer, and metamaterials, starting from fall 2017. Our interdisciplinary research project requires students having strong experimental or theoretical skills in one of the following areas: electromagnetics, optics and photonics, thermo-fluids and heat transfer, applied physics, and cleanroom nanofabrication.

References:

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2- K.Kim et al., "Radiative heat transfer in the extreme near field", Nature **528**, 387–391 (2015).
3- R. S. Ottens et al., "Near-field radiative heat transfer between macroscopic planar surfaces", Phys. Rev. Lett. 107, 014301 (2011).
4- A. I. Volokitin and B. N. J. Persson, "Near-field radiative heat transfer and noncontact friction", Rev. Mod. Phys. 79, 1291 (2007).
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