PHD Proposal

TOPIC: Adaptive glazing based on photovoltaic spatial light modulators to improve the energy efficiency of buildings.

According to the European Union (EU) Buildings Observatory, about 40% of energy consumption and 36% of CO_2 emissions in the EU are due to buildings. Improving the energy efficiency of buildings has therefore become one of the priorities in the fight against global warming. The development of so-called "adaptive glazing", whose transparency can adapt to the intensity of solar radiation, is one way of achieving this goal. Limiting the heating of interior spaces in summer by reducing the transmission of infrared rays while maintaining a high level of luminosity during less sunny periods will reduce energy consumption for air conditioning and lighting. It is in this context that the MaCEPV research team of the ICUBE laboratory has recently proposed a new concept of adaptive glass, called "PSLM" (for “photovoltaic spatial light modulator”). A PSLM glass is a hybrid thin-film device, composed of a nematic liquid crystal (LC) in direct contact with thin-film organic semiconductors. Its operating principle is based on the ability of the LC molecules to orient themselves in the direction of a low amplitude electric field and on the ability of the organic semiconductors to generate an electric field when exposed to light (photovoltaic effect).
This thesis topic will focus on the PSLM technology and will have as main goal
(a) to improve the stability of the devices, and
(b) to develop PSLMs capable of autonomously modulating the transmission of solar radiation in the infrared (IR) while remaining transparent in the visible range.

More specifically, to ensure a stable response under light, it is necessary to keep the ionic conductivity of the liquid crystal as low as possible. To achieve this objective, the project will include an in-depth study of the efficiency of trapping residual ions by bi-functional thin films. Recent work by the MaCEPV team demonstrated that such films can ensure both liquid crystal alignment and ion trapping. However, the underlying physical mechanism is not yet clearly established. It will therefore be necessary to identify and study the physical properties of the polymers responsible for ion trapping and to deduce optimal conditions for their utilization.

The development of autonomous PSLMs for modulating IR radiation will be based on the use of new organic semiconductors with a wide bandgap and IR polarizers that are transparent in the visible range. The large bandgap materials will be integrated as a photovoltaic element within the PSLM. They will absorb UV photons from the solar spectrum and convert photon energy into electrical voltage. IR polarizers will be developed from dichroic oriented conducting polymers. These materials are transparent in the visible range and have highly anisotropic absorption and reflection coefficients in the IR. The combination of these different elements are expected to lead to PSLMs that adjust, without power supply, the IR transmittance according to the intensity of solar radiation.

The project will be carried out within the MaCEPV team, in close collaboration with Dr. Nicolas LECLERC's team at ICPEES, for the synthesis of large bandgap organic semiconductors, and with Dr. Martin BRINKMANN's team at ICS, for the development of IR polarizers based on oriented polymers. It will also rely on an international partnership with the University of Southampton in the framework of the ANR collaborative research project "PSLM", which began in 2020 and will end in 2023.

Expected start date: Octobre 2022
University of registration: University of Strasbourg
Research unit: MACEPV team at the ICube Research Institute (https://macepv.icube.unistra.fr/)

Thesis Director: Thomas Heiser, ICube – Strasbourg University
Co-supervisors: Sadiara FALL, Yaochen LIN

Funding: Doctoral position funded by the University of Strasbourg, after passing a competition organised by the MSII doctoral school (http://ed.math-spi.unistra.fr/)

Profile of the candidate:
We seek a talented and ambitious researcher with a master degree in material physics and/or optoelectronic device physics. Ability to work in different teams and to communicate openly ideas and results. Have an equivalent passion for fabricating devices, carrying out experiments and modelling the observed properties. The research work requires a good knowledge in semiconductor physics and devices. Previous experience in liquid crystal devices will be strongly appreciated.