Photovoltaic spatial light modulators for self-powered smart windows

Yuhan Zhong[1,2], Jing Wang[1], Sadiara Fall[1], Yaochen Lin[1], Nicolas Brouckaert[3], Chaima Mahmoudi[4], Wenziz Muzuzu[4], Nicolas Leclerc[4], Malgosia Kaczmarek[3], Martin Brinkmann[2] and Thomas Heiser[1*]

[1] Laboratoire des sciences de l'Ingénieur, de l'Informatique et de l'Imagerie (ICube), Université de Strasbourg, CNRS, 23, rue du Loess 67037 Strasbourg, Cedex 2 France;
[2] Institut Charles Sadron, CNRS - UPR 22, 23 rue du Loess, Strasbourg 67034, Cedex 2 France
[3] University of Southampton, Southampton, United Kingdom
[4] Institut de Chimie et Procédés pour l'Energie, l'Environnement et la Santé, Université de Strasbourg, CNRS, 25, rue Becquerel 67085 Strasbourg Cedex, France
(Thomas HEISER: thomas.heiser@unistra.fr)

ABSTRACT:

Photovoltaic spatial light modulators form a new class of dynamic glazing that could be of interest to smart windows applications. The structure of the modulators includes a twisted nematic liquid crystal layer and an organic donor-acceptor bulk heterojunction. The latter is in contact with the liquid crystal and is used as a molecular alignment layer. In addition, under illumination, the bulk heterojunction generates an electric field that can be strong enough to orient the liquid crystal molecules homotropically and change the device optical transmittance, without requiring an external power source. The transmittance of this hybrid device adjusts spontaneously to ambient light within less than a second, with a sensitivity that can be tuned by a passive resistor. While this unique combination of features is desirable for smart windows, the device maximum transmittance in the clear state is currently limiting the possible scope of application.

In this contribution, we will firstly present the detailed structure, elaboration procedure and optical properties of a first generation of photovoltaic spatial light modulators that are based on commercially available polymer:fullerene blends and liquid crystals. The physical mechanism underlying the device operation will be demonstrated by crossed-polarizer intensity measurements as a function of incident light intensity and applied voltages. Furthermore, the time-dependent transmittance of a device that is exposed to a pulsed light source will be presented in order to assess its response time and reversibility.

In the second part we will describe various routes that we are following to improve the device optical properties in terms of maximum transmittance and sensitivity to ambient light. In particular, a new high band-gap semiconducting molecule that has been designed to achieve a highly transparent bulk heterojunction layer and increase the photo-induced electric field will be presented and its utilization in photovoltaic spatial light modulators will be shown.