Anisotropic n-type Thermoelectric Polymers prepared by polarity switching

Supervisor: Martin Brinkmann , directeur de recherche

Laboratory : Institute Charles Sadron, 23 rue du loess, 67034 Strasbourg (ZRR)

Description. Plastic electronics has become a major field of both fundamental research and innovative applications in industry. Organic Light Emitting Diodes (OLEDs) are now integrated in a routine way in new electronic items such as smartphones and TVs. New applications are now currently attracting researchers in plastic electronics, in particular in the field of thermoelectricity. Thermoelectric materials have the capability to convert a temperature gradient in electric current or vice versa. They can be used in numerous places such as industry, cars or intelligent textiles where lost heat could be recovered and converted to electricity. Efficient TE materials are usually semi-conductors or conductors and must show high electric conductivity, high Seebeck coefficients ($S=\Delta V/\Delta T$) and low thermal conductivity. So far, inorganic materials were dominating the field of TE, but, in the last decade, it has been demonstrated that polymeric systems such as PEDOT-Tos show remarkable TE properties.[1]

In this internship, we propose to investigate a simple method to fabricate stable and effective n-type thermoelectric polymer films. Therefore, we combine orientation of polymer chains in thin films using the method of high temperature rubbing developed at ICS and the mechanism of polarity switching that allows to turn a doped p-type material into an n-type one.[2,3] We will use a new doping strategy to achieve this objective by combining redox dopants and Lewis acids. In this work, we will investigate under which conditions the polarity switching p→n can be observed. In a second step, we will investigate the stability of the new n-like materials in inert atmosphere and ambient.

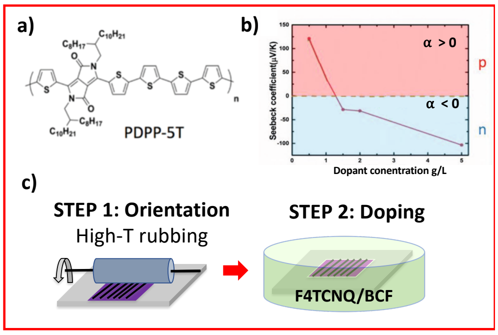

***Figure 1**. (a) Molecular structure of the donor-acceptor polymer. (b) Typical polarity inversion of the Seebeck coefficient upon heavy p doping of PDPP-5T. (c) Preparation method of aligned polymer films by rubbing (step 1) and sequential doping in solution of a dopant mixture F4TCNQ/BCF (step 2).*

The student will have the opportunity to work in a dedicated environment for plastic electronics i.e. perform all processing under controlled atmosphere. The student will perform the characterization of the devices from a structural point of view (transmission electron microscopy) and from the electronic point of view (conductivity and Seebeck coefficient) so as to draw structure-property correlations. Polarized UV-vis-NIR and FTIR spectroscopies will also be used to follow the doping processes.[4] The student will be integrated in an international team working on two collaborative projects on n-type TE materials (ITN Horates and ANR Thermopolys) as well as other projects (ANR TRIPODE and SMOOTH). The successfull applicant will be invited to pursue for a PhD that is funded by the ANR TRIPODE.

(1) O. Bubnova et al., *Nat. Mat.* **2011**, 10, 429.
(2) H. Zeng, M. et al. *Advanced Electronic Materials* **2021**, *7*, 2000880.
(3) S. Guchait, Y. Zhong, M. Brinkmann, *Macromolecules* **2023**, *56*, 6733.
(4) S. Guchait, et al. *Advanced Functional Materials n/a*, 2404411.

Contact: Martin Brinkmann; e-mail: martin.brinkmann@ics-cnrs.unistra.fr