Title of the research topic	Mxene synthesis in colloidal solution and applications for dye-sensitized and perovskite solar cells
Laboratory or Company	Laboratoire de Réactivité et Chimie des Solides, CNRS UMR7314
Laboratory Director	Mathieu Morcrette
Address, Country	Hub de l'énergie, 15 rue Baudelocque, Amiens
www Link	https://www.lrcs.u-picardie.fr
Master thesis Advisor(s)	Frédéric SAUVAGE
Phone	+33 3 2282 5792
e-mail(s)	Frederic.sauvage@u-picardie.fr

Scientific Project :

MXene materials are a class of 2D inorganic compounds, extending the graphene family, which are combining high conductivity, excellent electrocatalytic activity with semi-conducting properties. They were rapidly explored in the field of supercapacitors and batteries and afterwards in catalysis, optical displays (SERS, photodetectors…), gas sensors or biomedical applications. However, their semi-conducting properties, layer structure and high conductivity can potentially be of interest for photovoltaic applications, more particularly in the fields of dye-sensitized solar cells (DSSC) and perovskite solar cells (PSC).
The objective of this master thesis is to explore such new possibilities offered by the Mxenes for DSSC and PSC. A particular emphasizes will be given to the synthesis of the most conductive $Ti_3C_2T_x$ and its elaboration within a very well dispersed colloidal solution which can be used afterwards to elaborate optically thin and transparent films by spin-coating technique. Possible substitution of Ti by other transition metals (ie. Nb and Mo) will be envisioned depending on the results to improve electrocatalytic activities, conductivity or transparency.

The properties of optically transparent Mxene films will be evaluated in these two types of PV technology: 1/ as a new type of counter-electrode for totally transparent and colourless NIR-DSSC, for which our laboratory pioneered this new technology achieving a level of average visible transparency of more than 80% (a value similar to the transmittance of a piece of glass) and 2/ as a new buffer layer and electron back-contact to replace gold for semi-transparent PSC based on $CH_3NH_3PbBr_3$ or $CH_3NH_3PbBr_{3-x}Cl_x$. This work will be integrated into a H2020 EU project (IMPRESSIVE, https://impressive-h2020.eu) which aims at the development of non-intrusive, fully transparent and colorless PV modules. The properties of Mxene which are activities not actually covered by the consortium can pave the way to new improvements and future directions for the technology development roadmap of IMPRESSIVE. The candidate needs to show high motivation for this project, good skills in materials science and will take part of the consortium discussions. The candidate will have access to state-of-the art equipments.

Figure 1: Transparent PV cell based on near-infrared sensitization of a dye solar cells developed at LRCS (CNRS UMR7314)

Techniques used :
The Mxene films and full devices will be characterized by using conventional characterization techniques (XRD, UV-Visible absorption spectroscopy, SEM-TEM…) but also by time-resolved spectroscopies (Time-resolved photoluminescence and/or transient absorption spectroscopy). The PV properties will be assessed by (J-V) curves measurements under illumination and IPCE measurements. Stability evaluation will be carried out according to a standard accelerated test protocol. All these techniques are available in the laboratory.

Recent publications related to the topic :
Y. Gogotsi, B. Anasori ACS Nano 2019, 13, 8491−8494