Reg. No: 2021/43/O/ST4/00017; Principal Investigator: prof. dr hab. Marcin Ziółek

Project: „Electron transfer processes in multi-dye sensitized solar cells studied using ultrafast laser spectroscopy”

The main aim of the project is to study charge transfer processes between active dyes (absorbers) in modern dye sensitized solar cells (DSSC). This research will provide a better understanding of how these systems work and indicate ways to further improve their performance and stability.

The performance of dye solar cells under standard outdoor solar illumination is lower compared to competing photovoltaic technologies, but recent discoveries have shown that DSSCs achieve an outstanding efficiency of over 34% under low indoor lighting conditions. This feature should enable the use of DSSCs to power small home appliances, such as those connected to the Internet of Things. Another advantage of DSSC is the possibility of obtaining different colors and semi-transparency of devices (Fig. 1), which can be used, for example, in decorative elements or window facades.

Fig. 1. Demonstration DSSC device with a single MK2 dye with dimensions of 10 x 10 cm made in our research group. On the left: active dye covers the surface of the eagle from the AMU logo, the rest is filled with electrolyte. On the right: a photo cell in front of the building of the Faculty of Physics, AMU.

In DSSCs (as well as similar photovoltaic technologies based on organic materials), the use of a second absorber has become one of the key ways to increase efficiency in recent years. Despite this, the mechanisms underlying their increased efficiency are still not well understood. Therefore, the main goal of the project is to determine the rate constants and the efficiency of electron transfer between different absorbents (dyes). Research should reveal the role of electron transfer between active materials, or explain how the presence of one material affects the performance of the other. The main methodology for measuring the above systems will be the use of ultrafast laser spectroscopy with selective excitation of individual absorbers, especially the femtosecond transient absorption technique.

The research on charge-handling processes planned in this project should make a significant contribution to basic knowledge in important fields related to the use of organic-inorganic systems in materials science, nanotechnology and the production of "green" energy. We hope the project will also increase the use of ultrafast transient absorption in the research community involved in the study of complex solar energy conversion systems.