Let the world see Taiwan: Taiwan and United States scientists unite to solve the energy conversion efficiency of perovskite solar cells

Source: National Taiwan University Newsletter, Issue 1315
Author: Professor Yu-Ming Chang, Center for Condensed Matter Sciences, National Taiwan University
Translator: Tianran Chen, PhD Candidate, Department of Physics, University of Virginia

Every time I watch Po-Lin Chi's "Beyond Beauty-Taiwan from Above" documentary, I cannot hold my tears. The reason behind should be our affection and love of Taiwan, our motherland. Po-Lin Chi, with his more than 20 years of aerial photography professionality, voluntarily gave up his civil service pension, took his house to get bank mortgage loans, risked his life for each flight photography, only to get the achievements of this documentary so that we can see the beauty and sorrow of the land of Taiwan. After watching it, more Taiwanese are willing to pay attention to the land of Taiwan, and resort to specific actions to change some of the unpleasant surroundings. Being older, more and more I believe that this is the charm and power of "telling stories professionally".

Today, I would like to share with you readers a story about academic professions. The story begins with "having friends from afar".

Last year, Prof. Seung-Hun Lee, Department of Physics, University of Virginia, was invited to attend an academic conference in Taiwan. He also arranged for a visit to Dr. Wei-Liang Chen of Center for Condensed Matter Sciences (CCMS), an old friend for 30 years. As usual, we arranged Prof. Lee to share their latest research results of organic-inorganic hybrid perovskites (HOIPs) [1] at CCMS. After the academic talk, he visited our Ultrafast Laser Spectroscopy Laboratory and shared dinner with us. Originally, we thought that this was just a courtesy visit of a foreign scholar during his stay in Taiwan, and the story was to end there.

Surprisingly, although his original intention was only to meet his old friend, after talking about the lab's core technology in laser spectroscopy accumulated over the past twenty years, the two friends decided to launch an academic collaboration between his and our group. After nearly one year of close discussion on experimental design, experimental results analysis, and review and defense of the paper, we finally published our first co-author academic paper "Origin of Long Lifetime of Band-Edge Charge Carriers in Organic-Inorganic Lead Iodide Perovskites " on PNAS on July 18, 2017 [2].

HOIPs, as solar cell materials, have attracted great concern in recent years. Over the past five years, the best record of its energy conversion efficiency has almost reached that of commercial silicon solar panels ~ 22% [3]. Why HOIPs have such high energy conversion efficiency? This problem confuses physicists all over the world.

In this academic joint work between Taiwan and US teams, the Taiwan team, led by Dr. Yu-Ming Chang, CCMS, is responsible for the experimental design of photoluminescence spectrum and time-resolved photoluminescence, as well as measurement and analysis of HOIPs materials in the variable temperature environment (-196 °C ~ 350 °C). The photoluminescence spectrum research results of the Taiwan team provide the most direct and critical experimental evidence for the high efficiency of HOIPs (see captions of Fig. 1).

The research on the photoelectric properties of HOIPs is one of the most competitive research fields in the world. The goal of the collaboration between Taiwan and US multinational teams is to challenge the core of this research topic: try to solve the Physical mechanism for the high conversion efficiency of HOIPs (detailed description of two).

It is worth mentioning that the main research contributions of the Taiwan team are to build the world’s unique "Variable Temperature Laser Scanning Confocal Spectroscopy Microscope" within three months after confirmation of the overall research ideas and directions, and to obtain the critical laser spectrum results on the sample. The reason that US team invited us for collaboration after visiting our laboratory is their affirmation and confidence in our professional ability in laser spectroscopy. We believe that the publication of this paper will let the world see Taiwan's strength in the research of emergent materials using laser spectroscopy.

As a summary of the Taiwan and US teams’ academic collaboration, the expenditure on the Taiwan side are as follows: the lecture and meal costs during Prof. Lee’s stay at Taiwan is 5,000 NTD, the shared PNAS publication fee is 900 USD, and the expenditure for the sincere technological and academic exchanges between Taiwan and US teams was none.

Above is the story that I want to share with you.

How can we let the world see Taiwan's academic excellence? After the two rounds of the 50-billion-for-5-years funding on Taiwan’s higher education from the Ministry of Education in the past decades, are we better or still lost in our pursuit of academic excellence vision and goals? Which story do you want to share with the young students in the future?

References (web-linked):

[1] Chen T, et al. "Entropy-driven structural transition and kinetic trapping in formamidinium lead iodide perovskite", Science Advances 2 (10), e1601650 (2016).

[2] Chen T, et al. "Origin of long lifetime of band-edge charge carriers in organic-inorganic lead iodide perovskites", Proceedings of National Academy of Sciences 114 (29), 7519-24 (2017).

[3] Sivaram V, Stranks SD, Snaith HJ, "Outshining silicon." Scientific American 313.1: 54-59 (2015).

This article is published on the "National Taiwan University News" and "Physics Bimonthly".

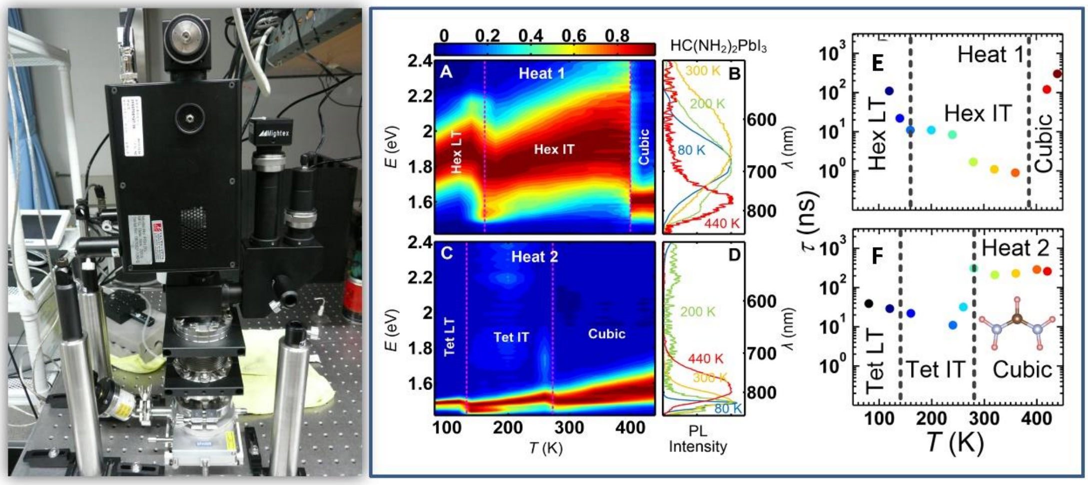

Figure 1 : (left) The Variable Temperature Laser Scanning Conjugate Focus Spectroscopy Microscope built by the Taiwan team. (right) Upon two different heating processes, the temperature-dependent photoluminescence spectra (A, D) and time-resolved photoluminescence lifetime (E, F), when FAPbI3 goes into a cubic phase, significant increases of photoluminescence lifetime are observed upon both processes.

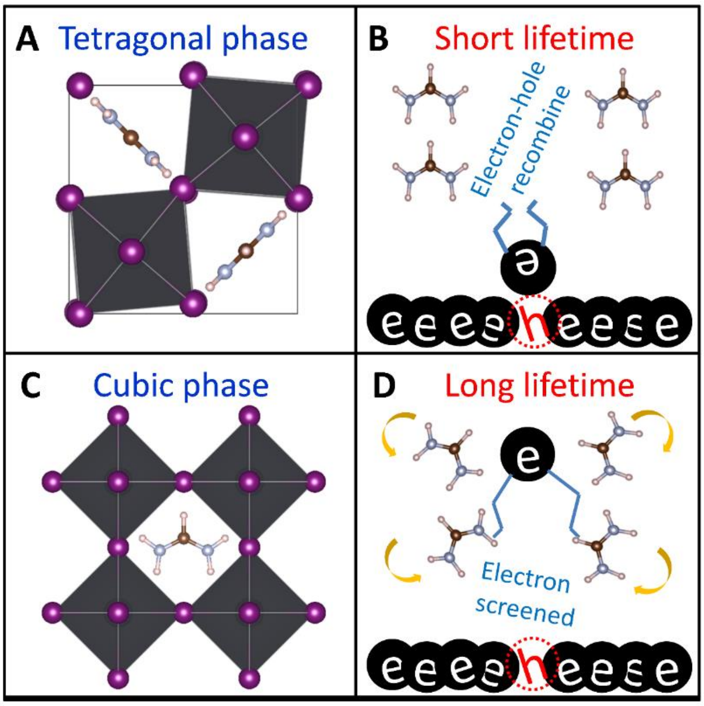

Figure 2 : The screening effect of organic molecules effectively prolongs the lifetime of photoelectrons and enhances the energy conversion efficiency of HOIPs. (A, B): When FAPbI3 is in a tetragonal phase, FA+ cations cannot rotate freely, thus cannot effectively screen the recombination mechanism of photoelectrons and holes. (C, D): When FAPbI3 is in a cubic phase, FA+ cation can rotate freely, providing excellent screening effect on the photoelectrons.