Current developments of organic solar cells in Japan

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Abstract

Three types of organic solar cells (OPV, DSC, and PVK) are being developed equally in many groups in Japan, including Kyoto University, Tokyo University, Yamagata University, and many companies. We organized organic solar cell research consortium as an academic and industrial sector cooperation network more than 4 years ago. The maximum PCEs of DSCs (12%), organic thin-film solar cells (11.7%), and perovskite solar cells(20.8%) have been already successfully achieved but still lower than those of silicon-based solar cell(27.0%). For the higher efficiency of hybrid organic solar cells, tandem solar cells with silicon-based solar cells are being developed, for which many types of multi layered structure fabrication process of the organic thin films and metal oxides layers, are developed.

Among them, only two companies have developed OPV, one for energy harvesting use for sensor networking and another for solar sharing.

Wireless sensor network becomes widespread utilizations into home and offices to keep the comfort environments and save energy. For this use, the development of the battery-less wireless sensor nodes are very important, and needs for the high performance indoor solar cells for stable and sustainable operation is quite high. Organic Photovoltaics (OPV) has the great potential for indoor photovoltaic use because ultra-thin organic layer has strong absorption of UV-visible light that is good spectral matching with indoor lightings. OPV module with 8 cells in series has prepared of the same size as the conventional amorphous silicon solar cells (a-Si) for indoor light harvesting. OPV and a-Si sensors are measured for their photovoltaic performance under the fluorescent light and demonstrated for energy harvester of wireless sensor network. The output power of OPV is comparable with that of a-Si solar cell at fluorescent light 1000lux. The data transmission rate of the wireless sensor node driven by OPV is 30-40% improved under the dim light condition compared to a-Si.

Using the light, flexible and the transparent character of OPV, another important use of OPV is now developed for green house power generation, which is called “solar sharing” in Japan. This revolutionary idea is based on the fact that most plants don't need all sunshine they receive in an open field. Plants do need light for photosynthesis, but only to a certain point. Everything beyond this saturation point does not increase photosynthesis rate and can even be harmful (e.g. causing more evaporation and lack of moisture). Solar sharing takes advantage of this fact - panels use the excessive sunlight for power generation while crops are cultivated below them. Solar sharing was invented by a Japanese Akira Nagashima in 2003 and today there are numerous trial projects all over Japan.

In this system, the agriculture and power generation have to be co-achieved, without any reduction of plants growth. In April 2013, Japan's Ministry of Agriculture released Guidelines that allow solar sharing on farmland and set basic rules to follow, so one would think that getting local committee's permission is easy, but that seems not to be the case yet. Currently, Si-based solar cells are used for this purpose. But we are developing the special OPVs with special spectral transparency for special light band for plant growth..

New application of PV for mobile electricity started recently in Japan. On 15th February, 2017, new PriusPHV has been on the market as the first commercially available solar cell loaded car. Although it has the HIT cell on the roof top, still power generation is not enough, because of the limitation of module size. To increase the power generation capacity, lighter cells are required. We are intending to use PVK solar cells for developing the lighter module fabrication.

Currently, we have achieved the cell efficiency close to c-Si solar cells. Lots of discussion still remain: Why does the perovskite cell show the high conversion efficiency ? it is just a light absorber with the bang gap of 1.5 eV, which is the best gap in a single cell structure, as far as the source is sunlight. Another advantage of a PVK cell if the HOMO level of the organic HTLs occupies typically 5eV,working as hole conductor with good contact with Au or Ag. The conduction band of oxide materials including perovskite materials gives close to 4eV, it turned out to be good for the electron transport. During the Symposium, I want to discuss much about the possibility of PVK solar cell in the future.

Figure1. Solar Sharing Farm System

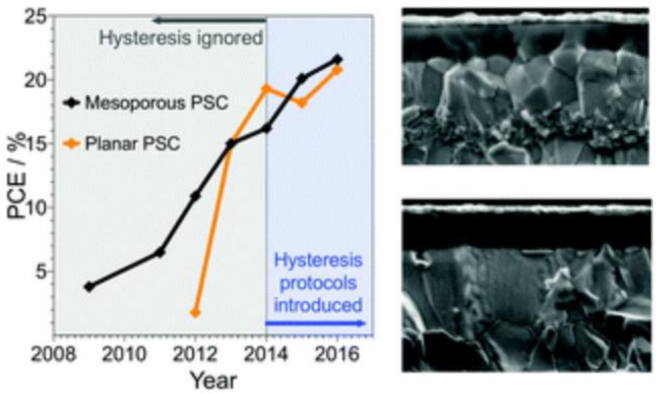

Figure2. Rapid efficiency development in PVK solar cells