Report for MERIT long-term overseas dispatch

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Abstract

I carried out my research on quantum dot solar cells (QDSCs) at Dr. Jean-Francois Guillemoles's laboratory in Institute of Research and Development on Photovoltaic Energy (IRDEP) during my stay in France from October 13th to December 24th. In addition, I fabricated thin-film SC samples at Dr. Stephane Collin's laboratory in Laboratory for Photonincs and Nanostructures (LPN).

Research theme

High efficiency solar cells are required not only for the cheap electric power generation by concentrated photovoltaic system, but also for the energy source of spacecrafts, solar planes, solar cars and so on. Intermediate band (IB) - QDSCs are one of the approaches to high efficiency SC. QDSC contains high density nano-scale semiconductor particles in a host wide gap material. The theoretical efficiency of IB-QDSC is 63% under concentrated sunlight with the photon absorption via IB made by quantum dots. QDSC are grown by molecular beam epitaxy method (MBE). To maximize the photon absorption from valence band (VB) to IB and from IB to conduction band (CB), the IB should be controlled to be at the optimized electron occupancy ratio. In my research, I fabricate n-doped QDSCs by Si doping, and investigate the effect of Si doping.

Research in France

I belong to Research Center for Advanced Science and Technology (RCAST) in the University of Tokyo. RCAST and IRDEP have established an international joint laboratory (NextPV), and many French students and staffs have visited RCAST. The laboratory of Dr. Jean-Francois Guillemoles is expert on the optical measurement on semiconductor SCs.

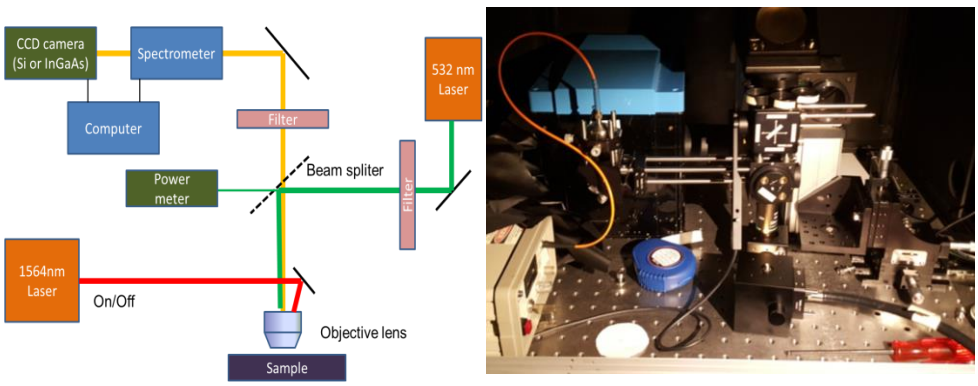

Fig. 1 The schematic measurement diagram (left) and actual picture (right) of Hyperspectra system.

A photoluminescence (PL) measurement system named "Hyperspectra" of IRDEP is a well calibrated PL system, and it can measure an absolute PL intensity map on samples. We can obtain chemical potential of carriers in the SC by using the absolute PL intensity map. I expected to estimate the n-doping effect in QDSC by measuring chemical potential in SC. In this research, I measured absolute PL map of QDSCs which I fabricated in Japan. The measurements were done under the illumination of Green laser (532 nm) and IR laser (1564 nm) in order to estimate IR absorption by QDSCs. It was observed that PL intensity under green laser was decreased by adding IR laser. This result suggests a 2 step photon absorption at room temperature. In Japan, I was only a user of optical measurement system which had been set up by staffs. However in France, I started from assembling the hyperspectra system and calibrate its system. I learned so many fundamental things for optical measurement.

In addition, I processed on my QDSC samples to fabricate thin film SCs at Dr. Srephin Collin's laboratory in LPN. This laboratory is expert on etching process for thin film semiconductor devices. I also fabricated thin film SCs by myself in Japan, but I learned some techniques at LPN, for example, defending the sample edge during etching processes.

Life in France

At IRDEP, people start working at 9:00 am and leave the laboratory at 6:00 pm. They are not allowed to work after 8:00 pm because the gate of the laboratory closes at 8:00 pm. Every staff seems to act in well considered plan, and doesn't act like "Try anyway", because they cannot work overtime. The staffs have 1 hour lunch and 0.5 ~ 1 hour coffee time everyday. I felt that they make well considered plan in the enough communication among members.

I think that the English skill of French people is almost the same as that of Japanese people. Sometimes French people and I needed to repeat words in order to understand each other. However these experiences solved an inferiority complex about my English skill.

During 9 weeks my stay in France, I negotiated for research every day. I think these experiences will be worthy in my life.

Acknowledgements

I would like to express my gratitude to Dr. Jean-Francois Guillemoles, Dr. Laurent Lombez and people in IRDEP. And I also express my gratitude to Dr. Stephane Collin and people in LPN. In addition, I would like to show my appreciation to Prof. Okada and the laboratory members for a financial support, and to MERIT for giving me a chance of this overseas dispatch.