Corporate Internship (in Japan) for MERIT Course Work

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Company: KONICA MINOLTA, INC. **Period**: August 12th, 2020–October 31st, 2020

Purposes: Research on the development of highly efficient organic light-emitting devices (OLEDs) using new functional organic materials and learning techniques of OLED fabrications and evaluation of device performances

Details of internship: I visited KONICA MINOLTA to conduct research on the development of OLEDs using new functional materials. So far, I have studied the functional organic materials in Isobe group such as linear oligo-*meta*-phenylene (LOMP) which was found to work as efficient base materials of single-layer OLEDs. In those studies, I have focused on the design and synthesis of new organic functional materials but asked the coworkers from KONICA MINOLTA to fabricate devices using the materials and to evaluate their device performances as well. However, it is necessary to understand in detail 'How OLEDs are fabricated and evaluated?' to properly interpret the results obtained from the analyses of the device performances and devise solutions for difficult problems that the previously developed materials have. To achieve a chance to learn OLEDs in more detail through experiments, I applied for the MERIT internship. During the internship, collaborating with Dr. Hideo Taka from KONICA MINOLTA (Department of Science, The University of Tokyo, Collaborative Researcher), an expert on organic electronics devices, I was engaged in the fabrications and evaluations of OLEDs using new functional materials. For the research on the development of OLEDs, a lot of apparatus including a very large vacuum vapor deposition machine are necessary. In this internship, I was allowed to utilize a facility for the research on OLEDs maintained by KONICA MINOLTA in the School of Science Bldg. 4. (Originally, we planned the internship in KONICA MINOLTA, Hachioji sites, but due to the COVID-19, we changed the place of the internship.) As below, I briefly described the contents that I have learned during the internship.

Figure 1. Vapor deposition machine

Figure 2. Glove box

(1) How to fabricate OLEDs Substrate washing, vapor deposition, and sealing were experienced. I learned the way of washing substrates of OLEDs before fabrication of the thin films. In general, it is known that before washing, some impurities are often attached to the surfaces of the substrates which were prepared for device fabrication. For example, glass particles, tiny dust, and so on. The impurities attached to the surfaces of the substrate will cause either the current leakage in the device or the degradation of OLED performances. Therefore, to completely remove those impurities, at first, we should wash the substrates by using sonication. In the internship, I tried washing substrates following the washing methods of KONICA MINOLTA and acquired the techniques.

Next, I set the clean substrates on a tray in the glove box, then transported the tray to the vacuum vapor deposition machine (Figures 1,2). In the vapor deposition machine, a metallic mask was set under the substrates, and vapor depositions of organic compounds were performed. During my trials of the vapor deposition, Dr. Taka told me that some of the compounds showed significantly different characteristics of the vaporization. By the vapor deposition methods, compounds are heated to their sublimation temperatures via the graduate increases of current which flows in the compounds. Because some compounds possess endothermic properties, a relatively large current was required during the operation for heating to the necessary temperature, and other compounds showed a dramatic increase of sublimation speeds at certain temperatures. I needed to pay attention to these characters of compounds and carefully fabricated each layer in OLEDs because the speed of the vaporization affects the reproducibility of the device performances.

Finally, I sealed films in the device under a nitrogen atmosphere. Because the device performances can be deteriorated by the oxygen and water in the air, sealing is important to prevent contact with the air.

(2) How to evaluate the device performances Utilizing the IVL evaluation apparatus, I evaluated the device performances. In the case of the single-layer OLEDs using LOMP molecules, the device performances were mainly assessed with current-voltage characteristics and external quantum efficiency (EQE). I also learned the designs and the setting of the optical systems.

Comments: I acquired the important knowledge and techniques of device fabrication and evaluation of device performances through this internship. Because I was not familiar with the experiments on the device fabrications and optical instruments before this internship, I conducted the research always thinking about the reasons ‘Why these procedures are needed?’ to understand the device properties deeply. Besides, the discussions with an expert help me learn a lot; I noticed that some of the compounds require the careful adjustments of operations during the vapor deposition, and albeit the small differences in the device fabrication, it can greatly affect the device performances. Finally, the experiences obtained in the internship made me confident in my research on the development of efficient organic functional materials.

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