MLF Experimental Report	提出日 Date of Report 2017/4/5
課題番号 Project No. 2015A0137 実験課題名 Title of experiment Evaluation of interfaces in solution-processed organic light emitting devices 実験責任者名 Name of principal investigator Yong-Jin Pu 所属 Affiliation Yamagata university	装置責任者 Name of responsible person Norifumi Yamada 装置名 Name of Instrument/(BL No.) BL16 SOFIA 実施日 Date of Experiment 2016/3/21-23, 2016/12/16-18

試料、実験方法、利用の結果得られた主なデータ、考察、結論等を、記述して下さい。（適宜、図表添付のこと）

Please report your samples, experimental method and results, discussion and conclusions. Please add figures and tables for better explanation.

1. 試料 Name of sample(s) and chemical formula, or compositions including physical form.

ZnO nano particles (ZnO NPs) (40 nm)

polyethyleneimine ethoxylated (PEIE) (100 nm)

phosphomolybdic acid (PMA) (10 nm)

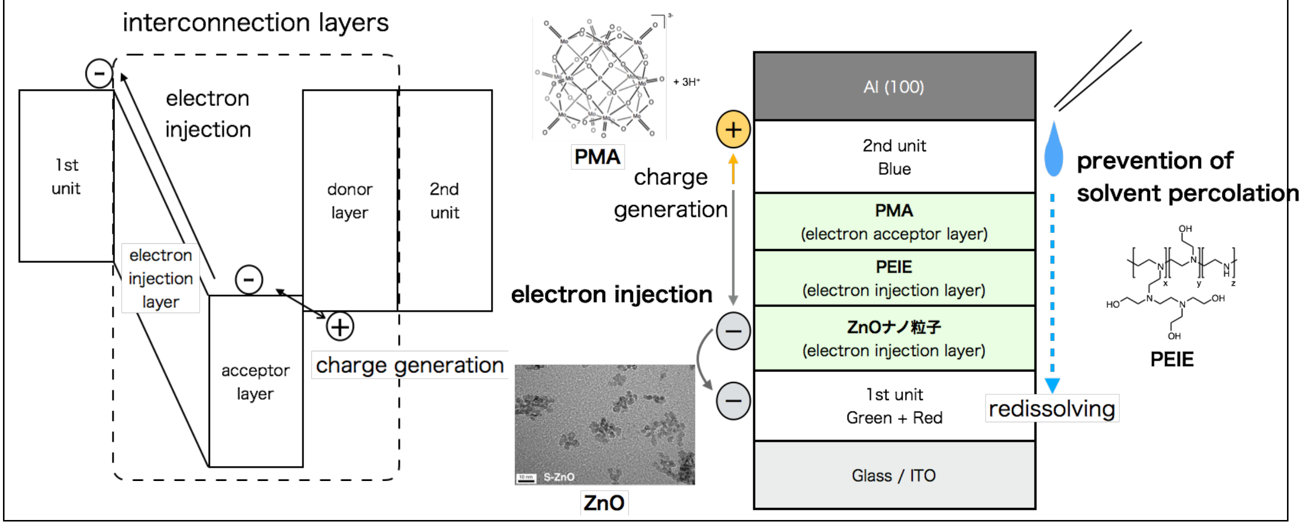
ZnO (40 nm)/PEIE (100 nm)

ZnO (40 nm)/PEIE (100 nm)/PMA (10 nm)

2. 実験方法及び結果（実験がうまくいかなかった場合、その理由を記述してください。）

Experimental method and results. If you failed to conduct experiment as planned, please describe reasons.

We studied stacking structures of ZnO/PEIE/PMA interconnection layers, in solution-processed multiphoton emission (MPE) devices. Influences of PMA-coating solvents and thermal annealing on the ZnO/PEIE/PMA stacking structure were investigated.



2. 実験方法及び結果（つづき） Experimental method and results (continued)

There was a concern that we could not evaluate the ZnO layers by neutron reflectometry (NR) because of the large roughness derived from the nanoparticles nature; however, we obtained clear Kiessig fringes from the ZnO layers and succeeded in the evaluation of the ZnO layers in determining thicknesses. The ZnO/PEIE layers were also able to be evaluated by NR. PEIE percolated into interspaces between each ZnO nanoparticles and the total thickness of the ZnO/PEIE layers was smaller than the sum of the thicknesses of the ZnO and PEIE single layers. PMA were coated either with solvents of acetonitrile (AN) or n-butyl acetate (n-BuOAc) onto the ZnO/PEIE layers. In same measurement times, a signal to noise (S/N) ratio of reflectivity curve of the AN-coated sample was smaller than that of the n-BuOAc-coated sample, indicating that the PEIE/PMA-interface of the AN-coated sample was rougher than that of the n-BuOAc-coated sample. High temperature annealing of the ZnO/PEIE/PMA films gave materials interdiffusion between the layers. These results accorded with results of evaluations of the ZnO/PEIE/PMA stacking structures by transmission electron microscope observation.

From these results, we succeeded in revealing relationships between the ZnO/PEIE/PMA stacking structures and the corresponding device characteristics. A device with the n-BuOAc-coated PMA layer had extremely higher driving voltages than that with the AN-coated PMA layer. This extremely high driving voltage in the device with the n-BuOAc-coated PMA was ascribed to lacks of the materials diffusion between the layers. A device with high temperature annealing of the PMA layer had extremely lower driving voltages than that without the high temperature annealing. Thermal interdiffusion of the materials gave good effects on the driving voltages. In summary, we succeeded in getting a guideline of fabrication methods for attaining more efficient interconnection layers.

We also performed in-situ experiments of solvent permeation of the ZnO/PEIE layers to reveal swelling degrees of the PEIE layers in each solvent. We expected that stronger interaction between AN and PEIE gave the rougher interface. However, we failed to evaluate the swelling degrees precisely because PEIE dissolved into the solvents. From preliminary experiments, we expected that binding effects between ZnO and PEIE gave insolubilization effects to PEIE layer in the solvents; however, the weak binding effects could not afford the expected inslubilization effects in long measurement times of 2 hours. However, we got fragmentary results about the swelling of PEIE layers and the results suggested that the swelling degree of PEIE in AN was larger than that in n-BuOAc. From these results, we consider that the interaction between PEIE and solvents are important parameters determining the stacking structure of the ZnO/PEIE/PMA layers and selection of PMA-coating solvents is important for a formation of appropriate stacking structures.