14C/2009G191

Application of Organic Photodiodes to X-ray Measurements - A Feasibility Study

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Introduction

Organic semiconductors have attracted considerable interest for use in photonic devices because of their potential use as flexible photodetectors for large area. In this study, to elucidate the applicability of organic photodiodes (OPDs) to radiation measurements, irradiation experiments with X-rays have been carried out.

Experimental

Fabricated Devices

Three OPDs were fabricated, two with heterojunction structures (OPD-a and OPD-b) and one with a bulk-heterojunction structure (OPD-c). OPD-a and OPD-b have a structure of ITO/α-NPD/td-PTC/Al with a sensing area of 4 x 4 mm^2, while OPD-c has a 300-nm-thick mixed organic layer between α-NPD and td-PTC layers.

Experimental Results

X-ray irradiation experiments were carried out at KEK-PF with these OPD devices. From the experiments with the heterojunction devices, it was that the relationship between the X-ray intensity and the X-ray induced current shows a good linearity. Also, for the OPD-b, the measured results were almost the same, which confirmed the reproducibility of the current device.

To investigate the effect of the mixed organic layer for increasing the X-ray induced current, we compared the X-ray induced current between OPD-a and OPD-c. From the results shown in Fig.1, it can be seen that the ratios of the induced current between OPD-a and OPD-c were about 3 times, where the organic layer thickness of OPD-c was 420 nm, which was about 3.5 times larger than that of OPD-a.

Discussions and Conclusions

These results show that X-rays can be measured using OPDs. Also it was shown that a bulk-heterojunction device can enhance charge production efficiency. Additional study is necessary to produce OPDs with thicker organic layers by adopting other fabrication techniques such as spin coating and dip coating. At present, it is still impossible to explain the decrease in current during irradiation and the relation between the energy deposition by X-rays and the induced current. Fundamental studies should be conducted to clarify the charge production and collection process. It can be said that, by increasing the organic layer thickness, the X-ray-induced current can be increased. However, considering our purpose to develop an OPD based dose monitor, at present, the efficiency is not high enough. Although the maximum layer thickness achieved by the vacuum vapor deposition is several hundred nanometers, we can fabricate a thicker OPD device using a spin coating or dip coating technique. Fabrication techniques must be reconsidered to enhance the efficiency. On the other hands, the energy dependence of the ratios between the induced current in OPD-a and OPD-c was still not explained. Also from these data, the need for further clarification of the charge production and collection processes in these OPDs is confirmed.

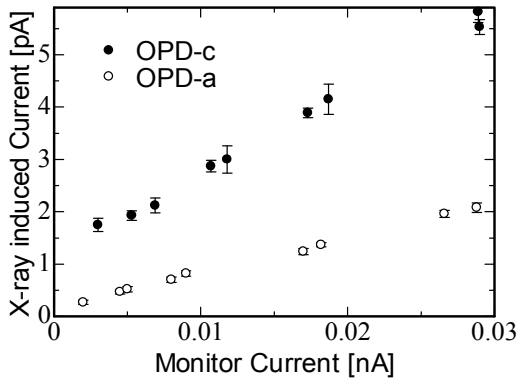

Fig.1 Comparisons of the X-ray induced current between OPD-a and OPD-c using mono-energy X-rays with energies of 40keV.

References

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