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Article / Book Information

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種別(和文)	論文要旨
Type(English)	Summary

（博士課程）
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論 文 要 旨

THESIS SUMMARY

系・コース： Department of, Graduate major in	Electrical and Electronics Engineering 系 コース	申請学位（専攻分野）： Academic Degree Requested	博士 Doctor of (Engineering)
学生氏名： Student's Name	Lei Lei Yin Win	指導教員（主）： Academic Supervisor(main)	Prof. Takaaki Manaka
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要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words）

Organic-inorganic hybrid perovskites are increasing technological interest not only for photovoltaic application but also for optical electronic devices. Despite considerable improvement of the power conversion efficiency, fundamental transport characteristics are still under investigations. The aim of this study concerns about the study of the carrier behavior such as charge injection and transport properties of organic-inorganic hybrid perovskite materials by using spectroscopic methods. The main proposed methods are electrical and optical measurements such as PL and EFISHG to directly visualize the carrier transport properties which make it possible to probe the carrier behaviors in materials. Because, the visualization for the carrier behavior of organic-inorganic hybrid perovskites, helps to understand their fundamental transport properties.

Firstly, for electrical characteristics, the simple electrical FET measurement was used to observe the steady-state electrical characteristics. Firstly, we couldn't see the modulated drain current at room temperature for SiO_2 based perovskite FETs, due to overwhelm of screening of gate field for the accumulation of migrated ion.[1] When the temperature decrease from 198 K to 77 K, we could see ambipolar characteristics with significant hysteresis due to the freezing the ion migration. Then we calculated the electron and hole mobility from the transfer characteristics curve. Moreover, the hysteresis at low temperatures revealed there was some unclear behavior rather than ion migration. Consequently, from lateral TOF method, the lateral transient transport current was dispersive and no plateau region that probably due to multiple trapping deposited film. For dispersive carrier transport, the transit time couldn't determine directly. We estimated the hole and electron transit time and carrier mobility based on double logarithmic plot and Scher-Montroll theory. The negative correlation of perovskite mobilties could be noticed due to the probability of collision for intrinsic

and extrinsic properties along the channel length.

Therefore, many aspects of the charge transport, such as the mechanism of carrier scattering and trapping, the role of ion screening, and the origin of unusual behaviors (hysteresis) could be explained by steady state FET measurement and lateral TOF measurement.

PL imagining technique provides direct insight into the nature of charge carriers such as mobility and ion migration and surface defects. Before PL measurement, we confirmed the charge is a source of PL mechanism and after that, we observed the fast response of PL quenching process. Under detail analyses of the time-dependent fluorescent images, we could clearly notice the two-step changing of PL; firstly PL enhancement might due to the high carrier transport phenomena then the gradually decreasing of PL intensity showed the migration of intrinsic ions in the perovskite thin film. By combining the lateral TOF method, we confirmed that this fast transient PL enhancement corresponds to the carrier motion and transit time could be directly evaluated. After that we successfully calculated the carrier mobility by direct visualization of PL experiment as 2.3×10^{-2} $cm^2V^{-1}s^{-1}$. The results of visualization of PL highlighted the valuable carrier information such as charge quickly diffuse through the film due to the high mobility, long diffusion length. Finally, important facts were intrinsic ions were spreading throughout the film.

Based on the transient electric field migration directly probed by the time-resolved microscopic optical second-harmonic generation (TRM-SHG) technique, we successfully detected the transient hole transport in the perovskite for the first time. From the spectroscopic point of view, SHG signal resonantly enhanced at the fundamental wavelength of around 1560 nm through the band-transition under the voltage application. Square dependence of the SH intensity on the applied voltage at the wavelength of 1560 nm clearly indicated the electric field induced process of the SHG. We could visualize the carrier motion in the channel of perovskite (FET) with this fundamental wavelength. Carrier mobility was estimated as 2×10^{-2} $cm^2V^{-1}s^{-1}$ by analyzing the transient carrier motion. TRM-SHG technique was also employed to investigate the effect of traps on the transient carrier motion. Based on the peak of the transient electric field distribution, trap density, and dynamic carrier mobility were separately estimated. TRM-SHG would be also useful in exploring trap affecting on the carrier dynamics in perovskite materials. The trapped charge density could be estimated as 1.2×10^{13} /cm^2 and we confirmed the trapped charge density gradually decreases in discharging process. We have also confirmed these trapped charges were

long-lived and gradually decreased after applying voltage. Thus, they could be the possible source of poor transport, low mobility, and source of hysteresis for perovskite materials.

This directly visualization of carrier behavior for organic inorganic hybrid perovskites which demonstrate excellent photovoltaic performance helps to understand their fundamental transport properties.

備考 ： 論文要旨は、和文 2000 字と英文 300 語を 1 部ずつ提出するか、もしくは英文 800 語を 1 部提出してください。
Note : Thesis Summary should be submitted in either a copy of 2000 Japanese Characters and 300 Words (English) or 1copy of 800 Words (English).

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