論文 / 著書情報
Article / Book Information

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Title(English)	Study of Cu(In,Ga)Se2 Solar Cells on Flexible Substrate
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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

専攻： Department of	電子物理工学　専攻	申請学位（専攻分野）： Academic Degree Requested	博士 Doctor of　（　工学　）
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要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

Harvesting sun energy via photovoltaics module is one of the solution to solve energy and environmental problem. To increase the usage of photovoltaics flexible solar cell is attracting owing to its less weight and wide field of application. Thin film solar cell with $Cu(In,Ga)Se_2$ (CIGS) absorber layer has potential to be used as flexible solar cells absorber layer shown by its high efficiency on rigid glass. As flexible substrate, polyimide (PI) film is one of the best candidate due to its stability and insulator characteristics which doesn't need additional barrier layer. Our group has proposed fabrication of CIGS solar cells on PI-coated soda-lime glass (SLG) which is easier to used and could be made thinner than conventional PI film. In this study, increasing the efficiency of flexible CIGS solar cells fabricated on PI-coated SLG was attempted by several experiments focusing on improving CIGS bulk and interface.

In the beginning, the problem and challenges that appeared during fabrication of flexible CIGS on PI-coated SLG was discussed. The problems on fabricating high efficiency flexible solar cells are mainly come from low deposition temperature approximately 450 ºC which is maximum temperature that PI film can tolerate. Three main problems were discussed, which are (1) deep notch in band profile, (2) alkali diffusion, and (3) interface recombination. The deep notch in band profile was caused by slow Ga diffusion at low temperature, in which reduce the V_{OC} and FF. While, alkali diffusion is a well-known problem in flexible CIGS because not using SLG that normally become the Na diffusion source. Moreover, low temperature deposition also contributes to different Na diffusion and other material which could reduce the carrier concentration. Therefore, investigation of alkali diffusion is necessary especially for CIGS on PI-coated SLG. Finally, the interface recombination is a common problem to CIGS solar cell that need to be solved both at high temperature or low temperature.

To suppress the effect of deep notch that reduce the performance of CIGS deposited at low temperature, single-graded band structure with Cu-deficient layer was proposed as a new band profile design. First, fabrication at high temperature was investigated to compare it with conventional three-stage method. Then, application on low temperature deposited CIGS was investigated, which achieved higher efficiency than conventional double-graded CIGS. The deposition of Cu-deficient layer proven to effective to reduce the interface recombination owing to hole repelling effect that increase the efficiency of single-graded CIGS from 12% to 14.5%.

Comprehensive investigation of alkali diffusion effect on CIGS both from substrate and external incorporation was conducted. NaF post-deposition treatment (PDT) was proposed to increase the carrier concentration, while KF-PDT was proposed to reduce the interface recombination by passivation effect. NaF-PDT increased the performance of CIGS deposited on alkali-free glass and achieving same efficiency with the one deposited on SLG. NaF-PDT also increase the efficiency of CIGS that already has Na diffusion from 13% to 15%. By conducting of KF-PDT, 17% of efficiency was achieved by passivation effect showed by hole formation in the surface. In the end, KF-PDT was conducted to newly proposed single-graded CIGS, however, it was shown ineffective. Measurement by Auger Electron Spectroscopy (AES) shown that the Ga contribute to the hole formation. This experiment indicated that Ga in the surface is necessary to form passivation layer with point contact that give beneficial effect to suppress the recombination at the interface.

To increase the efficiency further, combination of alkali treatment and deposition of Cu-deficient layer was proposed to maximize the passivation effect on CIGS surface. The deposition of Cu-deficient layer contributes to hole formation in the surface of alkali treated CIGS regardless of single-graded or double-graded. However, due to ineffectiveness of KF-PDT on single-graded CIGS, no significant improvement can be achieved. On the other hand, deposition of Cu-deficient layer on alkali treated double-graded CIGS proven to be effective to increase the FF further by passivate the point contact area by hole repelling effect that suppress the interface recombination and contribute to smoother CIGS/CdS interface by controlling the hole formation. Final efficiency exceeding 18% was achieved by combination of KF-PDT and Cu-deficient layer deposition which is higher than best efficiency of CIGS deposited on high temperature using the same equipment.

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。
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