論文 / 著書情報
Article / Book Information

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Category(English)	Doctoral Thesis
種別(和文)	論文要旨
Type(English)	Summary

（博士課程）
Doctoral Program

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　（　工学　） Doctor of
学生氏名： Student's Name	廣井　誉	指導教員（主）： Academic Supervisor(main)	山田　明　（教授）
		指導教員（副）： Academic Supervisor(sub)	—

要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

This thesis is described with the title of "Study of Se-free $Cu(In,Ga)S_2$ Solar Cells with KCN-free Process." Thin-film solar cells based on chalcogenide semiconductors are considered to be next-generation photovoltaics because of their strong potential for cost reduction compared with conventional Si-based solar cells. In particular, $Cu(In,Ga)(Se,S)_2$-based thin-film solar cells represent one of the most promising solar cells because of their high conversion efficiency compared with those of other thin-film solar cells. In the area of $Cu(In,Ga)(Se,S)_2$-based solar cells, Se-free $Cu(In,Ga)S_2$ is a very important material for future chalcogenide solar cells from an aspect of low-cost production. However, Se-free $Cu(In,Ga)S_2$ cells have two shortcomings that impede their large-scale production which are low cell-performance and the toxic KCN-etching process for absorbers. In this thesis, to demonstrate the potential of Se-free $Cu(In,Ga)S_2$ solar cells with KCN-free process, the growth process and device physics of Se-free $Cu(In,Ga)S_2$ solar cells are extensively studied from the low-cost and environmentally-friendly viewpoints while boosting the conversion efficiency. The main object of this thesis is to develop high performance Se-free $Cu(In,Ga)S_2$ solar cells with KCN-free and Cd-free processes. Two primary motivations underlie this study. One motivation is to develop a fabrication process free of both KCN and Cd to avoid environmental concerns. The other motivation is to improve the cell performance to satisfy technical requirements. This research was thus conducted to enable the future development of photovoltaic products based on environmentally-friendly and higher conversion efficiency photovoltaics on Se-free $Cu(In,Ga)S_2$. This thesis comprises seven chapters and brief descriptions of the chapters are provided as follows.

Chapter 1 includes background information and a description of the motivation for the study of solar cells. In this chapter, current issues about energy are discussed by comprehending the transition of energy consumption based on population growth until recent years. Furthermore, renewable energy, especially solar energy, is described as one of the promising energy resources to resolve current issues and maintain the affluent life in the future.

Chapter 2 explains the history and characteristics of $Cu(In,Ga)(Se,S)_2$-based thin-films and solar cells. Especially, the fundamental properties of Se-free $Cu(In,Ga)S_2$ thin-films and solar cells are described with the fabrication process from the point of view of the comparison of $Cu(In,Ga)Se_2$ solar cells.

Chapter 3 describes the Se-free $Cu(In,Ga)S_2$ absorber layer with KCN-free process. In this chapter, to improve the cell performance, the investigation of Se-free $Cu(In,Ga)S_2$ absorber and optimization of fabrication process are both mentioned based on Cu-poor composition, crystal growth, Ga depth-profile and minority carrier lifetime. As a result, it is mentioned that it has succeeded in improving the conversion efficiency of Se-free $Cu(In,Ga)S_2$ solar cells with KCN-free process for the first time in the world.

Chapter 4 explains the application of a $Zn_{1-x}Mg_xO$ buffer layer for Se-free $Cu(In,Ga)S_2$ solar cells as a Cd-free buffer layer. In this chapter, the effects of the $Zn_{1-x}Mg_xO$ buffer layer—specifically, a wide and controllable band-gap energy—are presented. It is shown that $Zn_{1-x}Mg_xO$ buffer layer enhances current density due to its wider band-gap than CdS buffer layer, in addition, open-circuit voltage is boosted by optimizing Mg content.

Chapter 5 investigates the impact of two interlayers. One interlayer is the MoS_2 layer at the interface between the Mo back-electrode and the Se-free CIGS absorber layers. The other interlayer is an intrinsic ZnO layer at the interface between $Zn_{1-x}Mg_xO$ buffer and transparent conductive oxide layers.

Chapter 6 presents the best results obtained in this work. In this chapter, the results of new world record efficiency which were 15.5% (certificated) and 16.9% (in-house) on Se-free $Cu(In,Ga)S_2$ solar cells were shown.

Chapter 7 concludes this thesis and gives future prospects for Se-free $Cu(In,Ga)S_2$ solar cells, in particular, the prospects for the development of future products are described in the context of the Se-free $Cu(In,Ga)S_2$ solar cells developed in the course of this work.

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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