# マテリアル先端リサーチインフラ利用報告書
# ARIM User's Report

【Release：2025.03.11】　【Update：2025.02.25】

## 課題データ / Project Data

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| 課題番号<br>Project Issue Number | 23JI1033 |
| 利用課題名<br>Title | Effect of post-treatment on the properties of copper/transparent conducting oxide/silicon |
| 利用した実施機関<br>Support Institute | 北陸先端科学技術大学院大学 / JAIST |
| 機関外・機関内の利用<br>External or Internal Use | 外部利用/External Use |
| 横断技術領域<br>Cross-Technology Area | 計測・分析/Advanced Characterization |
| 重要技術領域<br>Important Technology Area | 高度なデバイス機能の発現を可能とするマテリアル/Materials allowing high-level device functions to be performed |
| キーワード<br>Keywords | 電子顕微鏡/ Electronic microscope,高品質プロセス材料/技術/ High quality process materials/technique |

## 利用者と利用形態 / User and Support Type

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| 利用者名（課題申請者）<br>User Name (Project Applicant) | Wen Jauh Chen |
| 所属名<br>Affiliation | National Yunlin University of Science and Technology (Taiwan)Faculty |
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| ARIM実施機関支援担当者<br>Names of Collaborators in The Hub and Spoke Institutes | Koichi Higashimine |
| 利用形態<br>Support Type | 機器利用/Equipment Utilization |

## 利用した主な設備 / Equipment Used in This Project

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| 利用した主な設備<br>Equipment ID & Name | JI-008：原子分解能走査透過型電子顕微鏡 |

## 報告書データ / Report

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| 概要（目的・用途・実施内容）<br>Abstract (Aim, Use Applications and Contents) | n silicon heterojunction (SHJ) solar cells, the hydrogenated amorphous silicon (a-Si: H) thin layer is too low in transverse conductivity to effectively collect charge carriers horizontally over the metal electrodes. Additional transparent conductive oxide layers, such as Sn-doped In2O3 (ITO), are deposited at the top. In addition to charge collection, another essential function of the front-end transparent conductive oxide (TCO) layer is to act as an anti-reflective layer. The electroplating technology can effectively reduce the cost of electrodes. The Cu metallization process introduces SHJ solar cells, which is crucial to improving the SHJ solar cell industry's competitiveness. Some reports are on applying copper plating technology to SHJ solar cells. More work needs to be conducted on the effect of post-treatment on the properties of copper/transparent conducting oxide/silicon. The proposal produced front-side metallization by electroplating copper on crystalline silicon solar cells. A systematic study on the effect of post-treatment on the properties of copper/transparent conducting oxide/silicon will be investigated. Microscopic analysis will be used to understand the function of copper/transparent conducting oxide/silicon, the structural change, and the performance degradation. |
| 実験<br>Experimental | A single crystal phosphorus-doped silicon wafer with a pyramid texture was used as substrate. The textured silicon substrate was cleaned with acetone and H2SO4/H2O2 solutions. To remove the native oxide of the silicon, the substrate is dipped into a hydrogen fluoride solution before loading into the vacuum chamber. The TCO and copper films were sputter-deposited onto textured silicon substrates in a dc/rf-magnetron sputtering system. The TCO and copper films were deposited onto a textured silicon substrate at 25 ℃ during sputtering. TCO and copper films were subsequently sputter-deposited without breaking the vacuum to form the structure of Cu/TCO/Si. Electroplating copper on Cu/TCO/Si samples uses a chemical bath. The temperature of the electroplating bath was set at 25 ℃. The electroplating times of the copper layer are about 25 minutes. The electroplating copper metals on Cu/TCO/Si are designed as E-Cu/Cu/TCO/Si. To evaluate the effect of post-treatment on the properties of copper/transparent conducting oxide/silicon. The E-Cu/Cu/TCO/Si samples were annealed in the furnace at 150 and 200 ˚C for 30 min in Ar/H2 atmosphere. A JEOL-ARM 200F transmission electron microscopy (TEM) operating at 200 kV was used for microstructure examination. Peel force tests were conducted using a universal testing machine. All the samples were glued to a brass sheet. Cu ribbons (40mm x 1.5mm x 0.15mm) coated with Sn were hand-soldered on a 4 mm broad sample. The peel-off tests were conducted at an angle of 90˚ with a constant speed of 30 mm/min. The measured values were divided by width (4 mm) to obtain the real peel force. |
| 結果と考察<br>Results and Discussion | The low and high magnification TEM micrographs of the E-Cu/Cu/TCO/Si sample annealed at 200 ˚C are shown in Figure 1. The multilayer is preserved after annealing at 200 ˚C for 30 min. The structure of the as-deposited sample is identical to the sample annealing at 200 ˚C for 30 min. In the peeling force test of the post-annealed E-Cu/Cu/TCO/Si sample made by sputtering and electroplating. For the as-deposited samples, the average peel force value is about 0.37N/mm at the peeling angle of 90˚. The average peel forces are about 0.8 N/mm and 0.91N/mm at 150 and 200 ˚C, respectively. The average peel force increases as the annealing temperature increases. The results show that the adhesion strength of the E-Cu/Cu/TCO/Si sample can be improved by heat treatment. |

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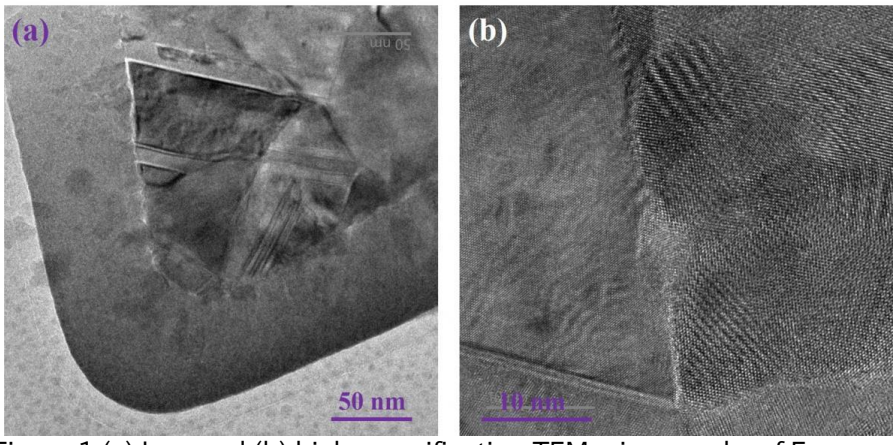
| 図・表・数式 1<br>Figures, Tables and Equations 1 |  <br>Figure 1 (a) Low and (b) high magnification TEM micrographs of E-Cu/Cu/TCO/Si sample annealed at 200 ˚C, respectively. |
| その他・特記事項（参考文献・謝辞等）<br>Remarks(References and Acknowledgements) | The authors thank Mr. Koichi Higashimine at the Center for Nano Materials and Technology, Japan Advanced Institute of Science and Technology, Japan, for his technical support. The authors also thank Dr. Tseng’ s laboratory at the Graduate School of Materials Science, National Yunlin University of Science and Technology, for their support..) |

## 成果発表・成果利用 / Publication and Patents

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| DOI（論文・プロシーディング）<br>DOI (Publication and Proceedings) | |
| 口頭発表、ポスター発表および、その他の論文<br>Oral Presentations etc. | |
| 特許出願件数<br>Number of Patent Applications | 0件 |
| 特許登録件数<br>Number of Registered Patents | 0件 |