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CTCI Science and Technology Research Scholarship

一階段濺鍍法製備銅銦鎵硒太陽能電池之製程開發與展望

Prospects and Development of Thin Film Cu (In,Ga) Se_2 Solar Cells by One-step Sputtering Process

國立清華大學 材料科學工程學系 博士班五年級 林姿瑩

指導教授: 賴志煌 教授

國立清華大學 NATIONAL TSING HUA UNIVERSITY

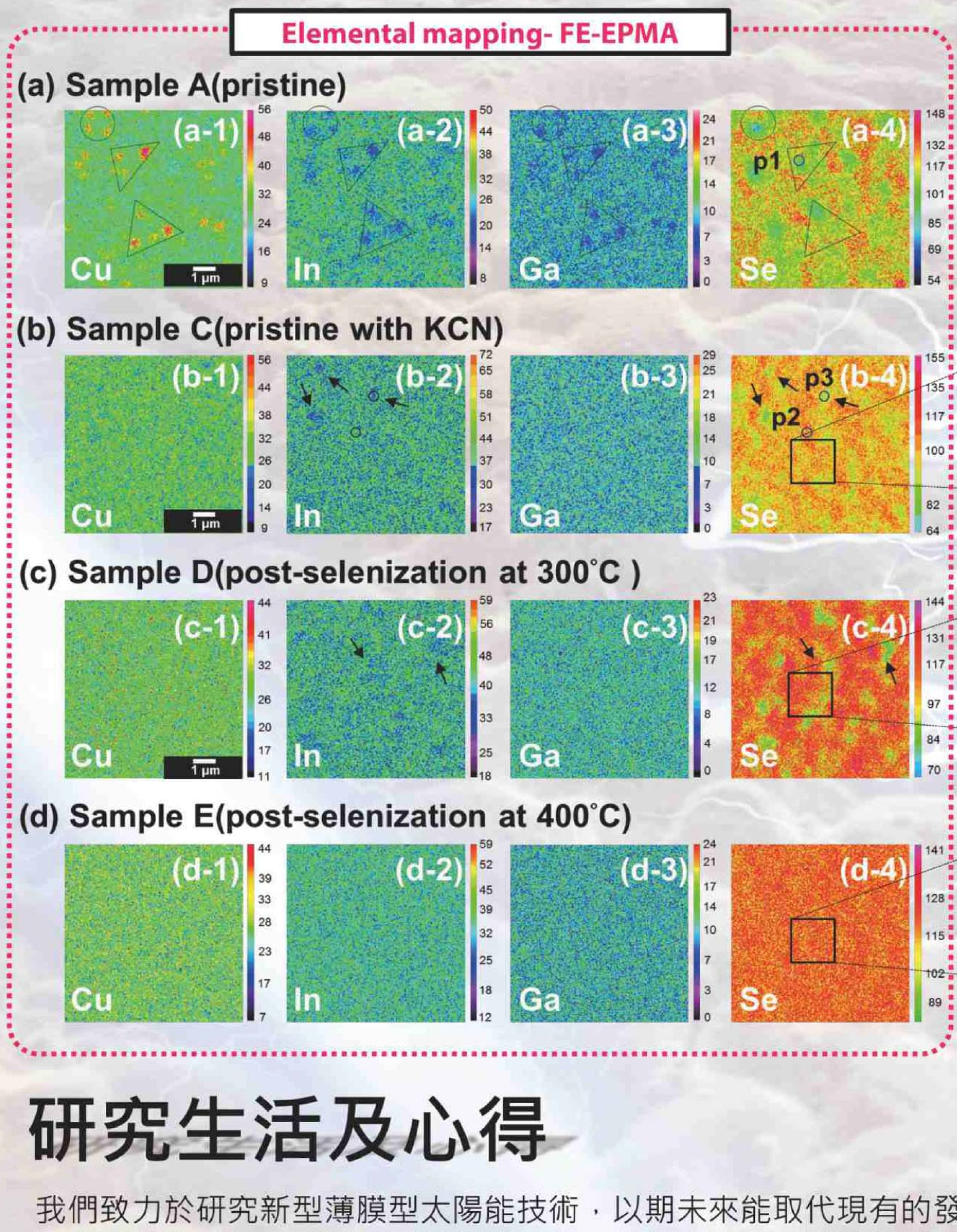
研究重點

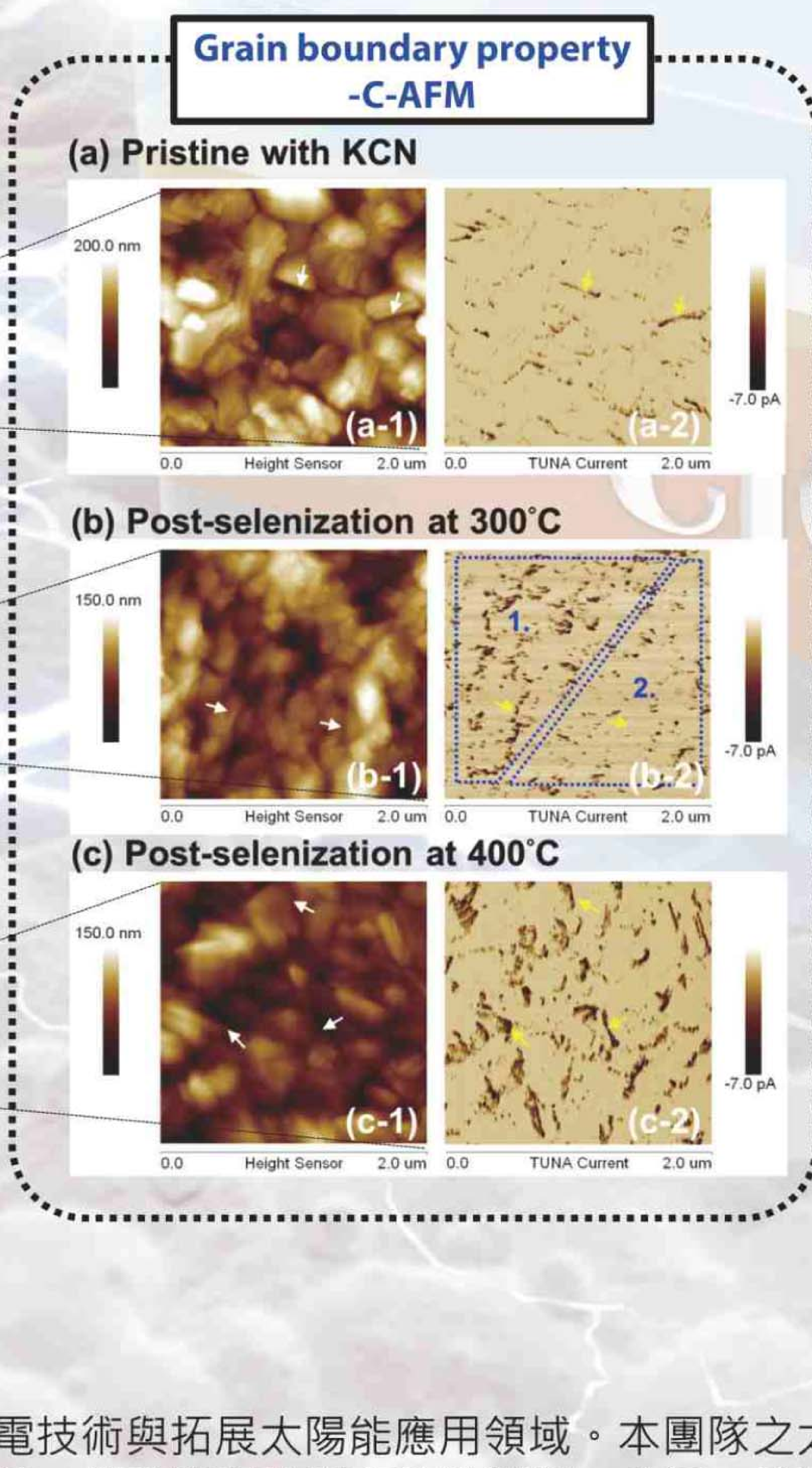
Chalcopyrite Cu(In,Ga)(Se,S)2 (CIGS)-based solar cells have been leading thin-film material candidates for incorporation in high-efficiency photovoltaic devices. CIGS solar cell technologies based on vacuum deposited absorber layers have driven the advancements with the highest efficiency records of 22.6% by three-stage co-evaporation. In order to speed up the mass production development and head toward industrial maturity, we have developed a simplified fabrication-"one-step sputtering" process. One-step sputtering process by using single quaternary target has been proposed several decades ago, but it usually needed the extra Se supply by post-selenization. In our group, conversion efficiency over 10% by one-step sputtering without extra Se supply has been demonstrated.

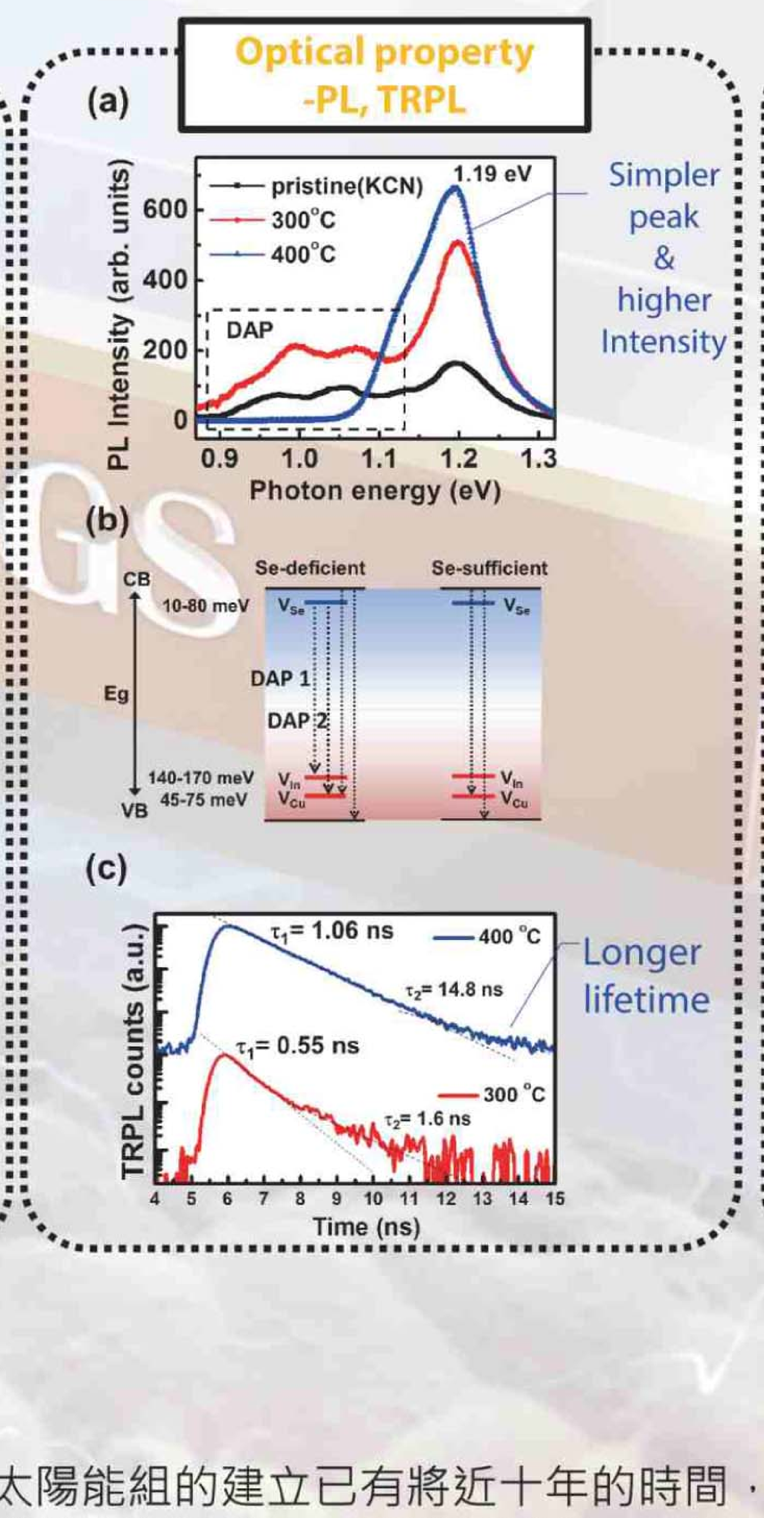
Even though the excess Se concentration (Se/metal>1) in CIGS films can be achieved by using a Se-rich target, Se-deficienent-related defects are still present for the one-step sputtered samples. This result implies that other factors in addition to the Se concentration may also influence the defect formation and thus cell efficiency. So far, the impacts of the overall Se concentration on solar cell performance has been studied; however, how the Se is distributed in CIGS films and how the local Se distribution affects the cell performance have not been clearly understood yet due to the challenges to acquire spatial composition distribution in hundred-nanometer scale. In this study, a promising nondestructive analysis by using field-emission electron probe microanalysis (FE-EPMA) is first demonstrated to directly probe the Se distribution within the depletion region of CIGS absorbers. We observe that Se-deficient-related defects are still exist in CIGS films even with high Se concentration but non-uniform distribution, leading to relatively low efficiency (~7%). By correlating photoluminescence spectra and conductivity mapping with composition distribution, we clarify that the uniform Se distribution is the key factor to suppress the defect formation and to enhance the p-n inversion at grain boundaries, resulting in significant efficiency boost to 12%.

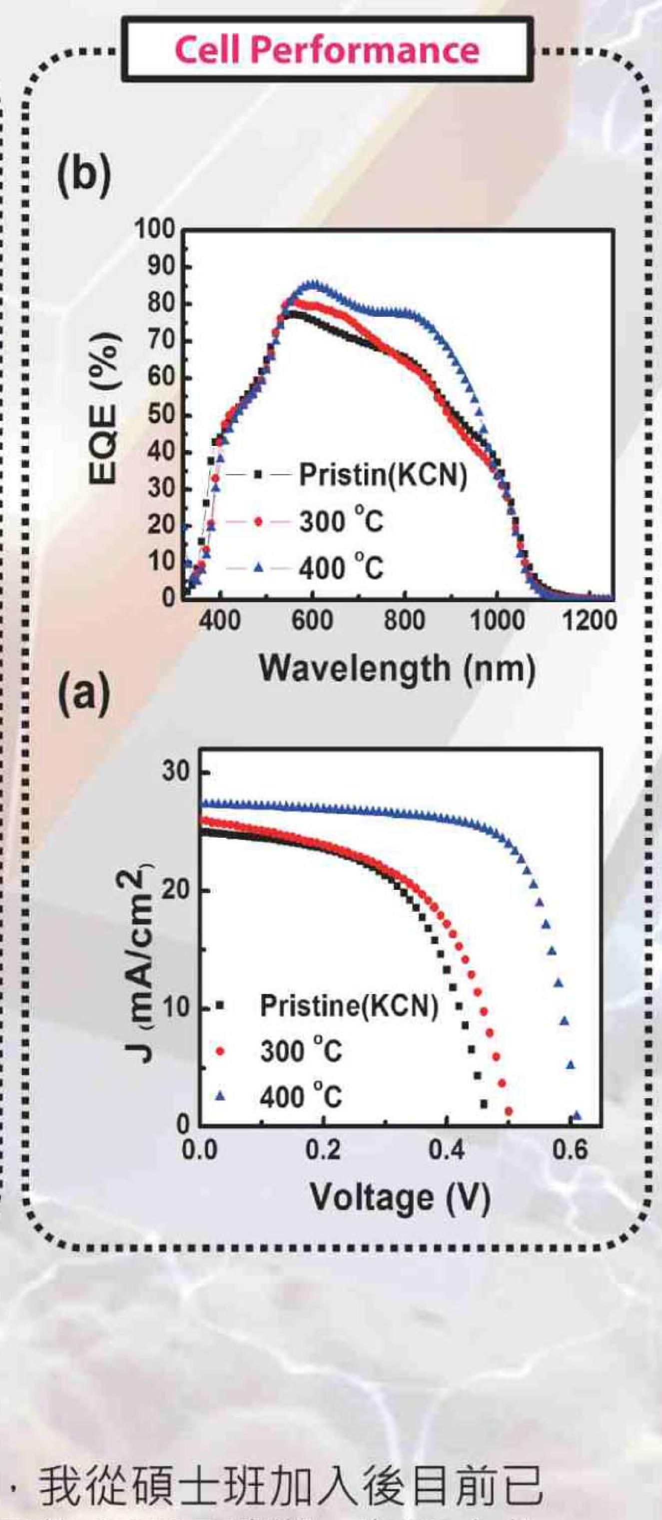
研究成果

Condition	Cu [at%]	In [at%]	Ga [at%]	Se [at%]	Cu/In+Ga	Ga/In+Ga	Se/metal
CIGS target	24.33	18.70	7.81	49.16	0.92	0.29	0.97
Sample A (pristine)	27.43	18.54	7.23	46.80	1.06	0.28	0.88
Sample C (pristine with KCN)	25.69	19.15	7.25	47.91	0.97	0.27	0.92
Sample D (post-selenzation at 300° C)	23.35	17.84	6.59	52.22	0.96	0.27	1.09
Sample E (post-selenzation at 400° C)	23.44	17.83	6.45	52.28	0.97	0.27	1.10









研究生活及心得

我們致力於研究新型薄膜型太陽能技術，以期未來能取代現有的發電技術與拓展太陽能應用領域。本團隊之太陽能組的建立已有將近十年的時間，我從碩士班加入後目前已是六年多的歲月，算是見證了篳路藍縷的草創時期到目前已開發完整，從前段至後段完善的製程、分析、檢測的整套技術。一路從無到有，多虧了許多不同時期一起努力的研究夥伴。未來將繼續延續自己對科學研究的熱忱，以材料人為期許，繼續從事材料與能源領域相關之研究，融合學術理論與實務應用，未來希望能對台灣社會在能源科技領域裡擔負起重任。

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