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高效率異質接面太陽能元件
Toward Highly Efficient Heterojunction Solar Devices: An Electrical and Optical Concurrent Design

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研究重點：

To achieve high efficient solar devices, concurrent engineering design involving electrical and optical perspectives in parallel is necessary. The heterojunction is presently popular design in the photovoltaics due to the low recombination rate, leading to high open-circuit voltages (V_{OC}). Here, we'll focus on boosting the efficiency of heterojunction solar devices.

First of all, hierarchical structures combining micropyramids and nanowires with appropriate control of surface carrier recombination represent a unique class of architectures for radial p-n junction solar cells that synergizes the advantageous features including excellent broadband, omnidirectional light-harvesting and efficient separation/collection of photoexcited carriers. The heterojunction solar cells fabricated with hierarchical structures exhibit the efficiency of 15.14% using cost-effective as-cut Czochralski n-type Si substrates, which is the second highest reported efficiency among all n-type Si nanostructured solar cells. This is also the first described omnidirectional solar cell that exhibits the daily generated power enhancement of 44.2%, as compared to conventional micropyramid control cells. The concurrent improvement in optical and electrical properties for realizing high-efficiency omnidirectional solar cells using as-cut Czochralski n-type Si substrates demonstrated here makes hierarchical architecture concept promising for large-area and cost-effective mass production.

Amorphous Si (*a*-Si)/ crystalline Si (c-Si) heterojunction (SHJ) photoelectrochemical cells can serve as highly efficient and stable photoelectrodes for solar fuel generation. Low carrier recombination in the photoelectrodes leads to a high photocurrent and high photovoltage. Both SHJ photoanodes and photocathodes are designed for high efficiency oxygen and hydrogen evolution. The SHJ photoanode with sol-gel NiO_x as the catalyst shows the current density of 21.48 mA/cm^2 at the equilibrium water oxidation potential. The SHJ photocathode displays excellent hydrogen evolution performance with an onset potential of 0.640 V and a solar to hydrogen conversion efficiency of 13.26%, which is the highest ever reported for Si-based photocathodes.

Keywords: Subwavelength-antireflective hierarchical structure, heterojunction solar device, surface passivation, grain boundary passivation, thin-film vapor-liquid-solid growth technique

Realizing High-Efficiency Omnidirectional n-Type Si Solar Cells via the Hierarchical Architecture Concept with Radial Junctions

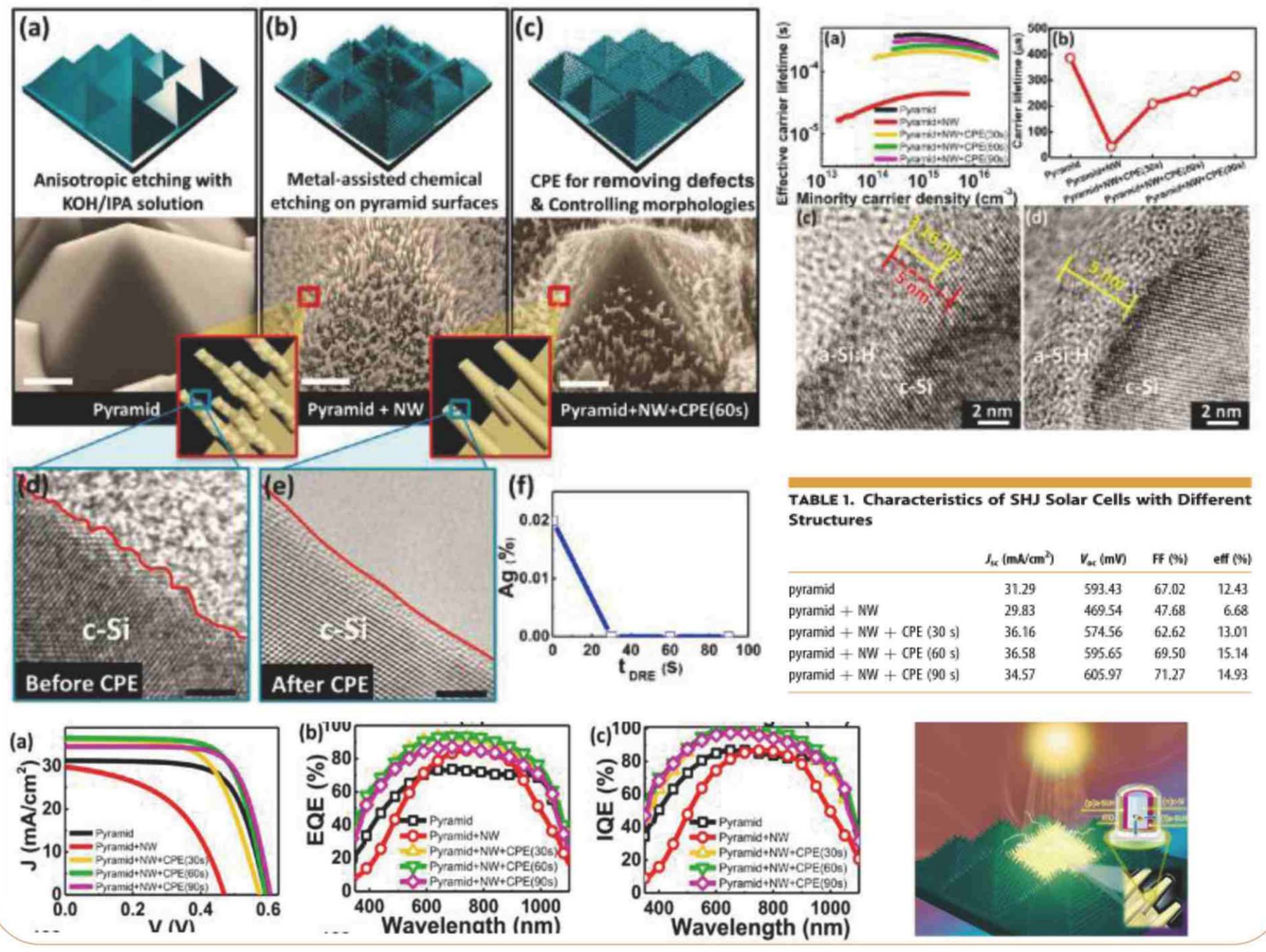
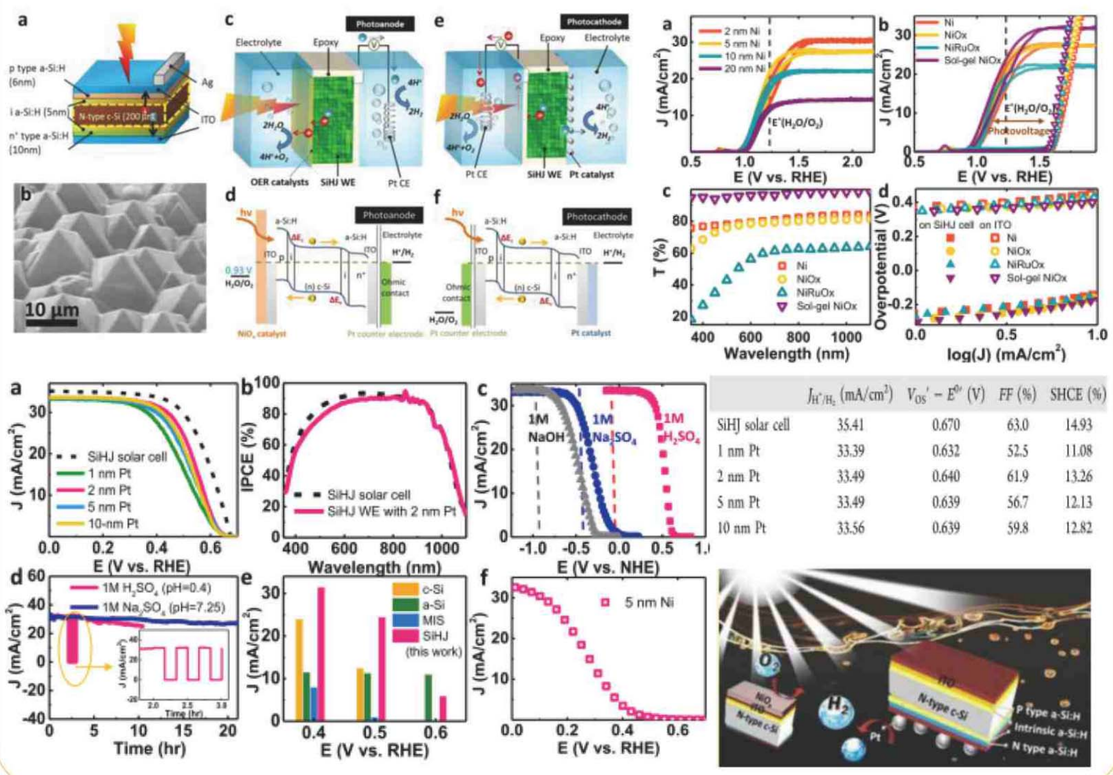


TABLE 1. Characteristics of SHJ Solar Cells with Different Structures

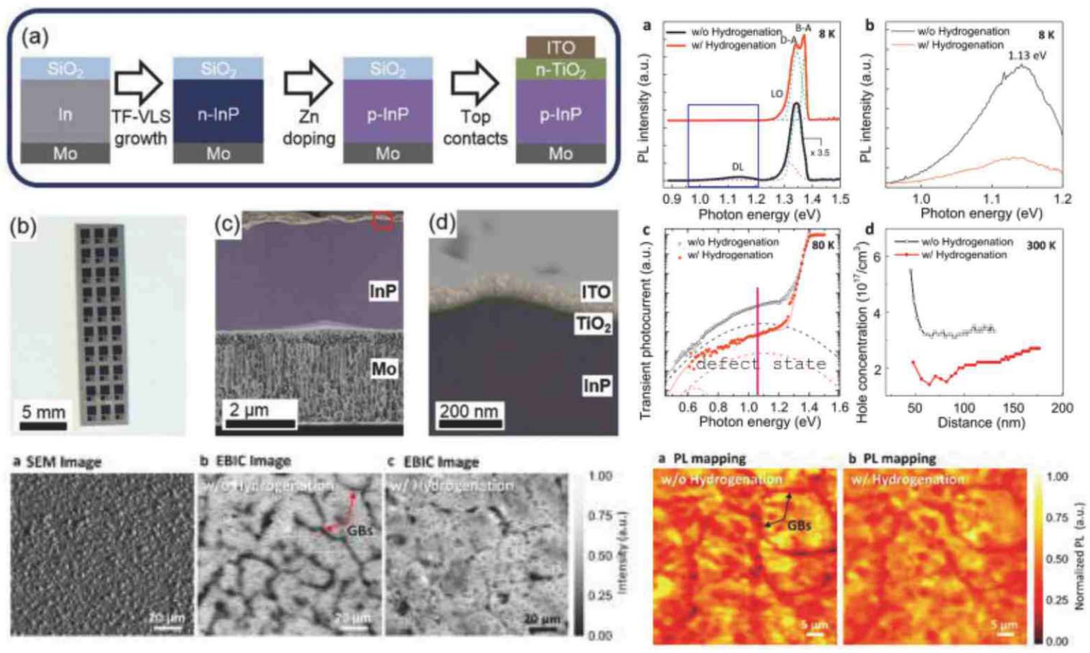
	J_{sc} (mA/cm^2)	V_{oc} (mV)	FF (%)	eff (%)
pyramid	31.29	593.43	67.02	12.43
pyramid + NW	29.83	469.54	47.68	6.68
pyramid + NW + CPE (30 s)	36.16	574.56	62.62	13.01
pyramid + NW + CPE (60 s)	36.58	595.65	69.50	15.14
pyramid + NW + CPE (90 s)	34.57	605.97	71.27	14.93

High-Performance a-Si/c-Si Heterojunction Photoelectrodes for Photoelectrochemical Oxygen and Hydrogen Evolution



	J_{H^+/H_2} (mA/cm^2)	$V_{OS}' - E^{0'}$ (V)	FF (%)	SHCE (%)
SiHJ solar cell	35.41	0.670	63.0	14.93
1 nm Pt	33.39	0.632	52.5	11.08
2 nm Pt	33.49	0.640	61.9	13.26
5 nm Pt	33.49	0.639	56.7	12.13
10 nm Pt	33.56	0.639	59.8	12.82

Increased Optoelectronic Quality and Uniformity of Hydrogenated p - InP Thin Films



研究生活及心得：

我於碩士期間，致力於奈米結構之光性研究與探討探。博士期間，探討不同材料之異質接面太陽能元件之光電同步設計，分析不同太陽能元件的光電條件，將適合的奈米材料與結構實際運用於各種不同太陽能元件，以增加元件效率。於UCSD進行太陽能水分解之研究，利用異質接面產生的光伏及結構設計，可達到高效率之光陰極及光陽極。於UC Berkeley學習利用VLS橫向成長大面積單晶三五族薄膜，並討論磷化銦薄膜異質結構在太陽能元件上的應用。

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