



HAL
open science

Hybrid Photovoltaics and Semiconductors

Baoquan Sun, Zhuoying Chen, Xinbo Yang

► **To cite this version:**

Baoquan Sun, Zhuoying Chen, Xinbo Yang. Hybrid Photovoltaics and Semiconductors. *physica status solidi (RRL) - Rapid Research Letters*, 2021, 15 (12), pp.2100393. 10.1002/pssr.202100393 . hal-03863111

HAL Id: hal-03863111

<https://cnrs.hal.science/hal-03863111>

Submitted on 21 Nov 2022

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Hybrid Photovoltaics and Semiconductors

Baoquan Sun,¹ Zhuoying Chen,² and Xinbo Yang^{3,*}

1. Institute of Functional Nano & Soft Materials (FUNSOM), Soochow University, 199 Ren'ai Road, Suzhou 215123, China

2. Laboratoire de Physique et d'Etude des Matériaux (LPEM), CNRS UMR 8213, ESPCI Paris, PSL (Paris Sciences & Lettres) University, France

3. College of Energy, Soochow University, 688 Moye Road, Suzhou 215006, China, E-mail: xbyang@suda.edu.cn

Solar energy is believed to play a key role in global energy system in the near future, because of its clean and renewable nature. Solar photovoltaics (PV), which convert solar energy to electricity, is currently a highly competitive technology that ready to contribute to the greenhouse gas emission mitigation. By the end of 2020, global installed solar PV capacity has reached ~ 707 GW [1], and the average PV module price has been reduced to 0.21 US\$/Wp [2], competitive to the conventional fossil energy. PV module price exhibits an impressive learning rate of $\sim 40\%$ from 2006 to 2020, indicating its cost reduces by 40% every time the cumulative capacity doubles. One of the most important driver for the module price reduction is the PV technology improvement, especially the device structure evolution and power conversion efficiency increase.

Currently, the PV market is dominated by the crystalline silicon (c-Si) PV technology ($\sim 95\%$ market share in 2020), and thin film PV technology (mainly CdTe and CIGS solar cells) occupies another 5% market [1]. Last few years have seen the c-Si PV technology switch from aluminum back surface field (Al-BSF) cell and passivated emitter and rear cell (PERC), which has occupied $\sim 80\%$ of the PV production in 2020. However, the PERC cell features a PCE limit of $\sim 24\%$ on industrial production line with technologies principally available [3]. The carrier recombination losses at the metal-silicon contact regions as well as the heavily doping induced issues (e.g. Auger recombination, bandgap narrowing and free carrier absorption) were identified as the key factors that limit the PCE of PERC cells. As predicted in Figure 1b, c-Si heterojunction solar cells with passivating contacts will be the next generation

high-efficiency PV production ($\geq 25\%$) after PERC [3]. In the meantime, emerging PV technologies, such as the perovskite and organic solar cells, are also attracted considerable attention thanks to their potential low-cost and flexibility. To overcome the theoretical PCE limit of single-junction solar cells, tandem device is of particular appeal. The most successful example is the perovskite/c-Si tandem solar cells, already achieving a high PCE of 29.5%.

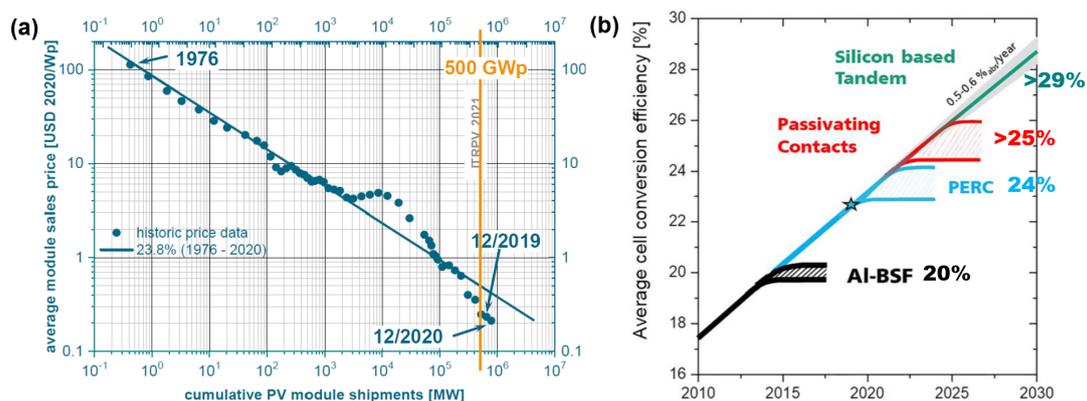


Figure 1 (a) Learning curve for module prize as a function of cumulative shipments; (b) Research and development roadmap of c-Si PV productions.

The current focus issue on Hybrid Photovoltaics and Semiconductors is dedicated to this endeavor. Cutting-edge works on photovoltaics technologies, including c-Si solar cells, perovskite solar cells, organic solar cells, tandem solar cells and semiconductor defects, are presented. Yu et al. achieved an impressive mass production PCE of 23.24% on industrial PERC cell with a high bifacial rate of 78% [4]. Two smart methods, prolonged annealing and CO₂ plasma interface treatment, were developed to increase the PCE of silicon heterojunction solar cells, resulting in a high PCE of up to 23.3% on industrial six-inch substrate [5,6]. Wang et al. presented a novel dopant-free electron-selective CsF₃ contact, achieving a high PCE of 21.27% at a low cost [7].

[1] PV report, Fraunhofer ISE, June 2021.

[2] International technology roadmap for photovoltaic (ITRPV), 12th Edition, April, 2021.

[3] M. Hermle, F. Feldmann, M. Bivour, J. C. Goldschmidt, S. W. Glunz, Appl. Phys. Rev. 7, 021305 (2020).



Baoquan Sun is a professor of Soochow University, China. He received his Ph.D. at Tsinghua University. After postdoc. research in the Cavendish Laboratory at Cambridge University and Los Alamos National Laboratory, he joined Institute of Functional and Soft Materials of Soochow University in 2008. His main research fields are nanostructured semiconductor materials, conducting inks, charge separation and transport, interface engineering for flexible electronics, light-emitting diodes, and silicon solar cells.



Zhuoying Chenis is a CNRS researcher (Chargé de recherche) working in the Laboratoire de Physique et d'Etude des Matériaux (LPEM, CNRS-UMR 8213) at ESPCI Paris, a unit of Paris Sciences et Lettres (PSL) University in France. She received her Ph.D at Columbia University in the city of New York. After being a postdoc researcher in the Cavendish Laboratory at Cambridge University, she joined CNRS in 2010. Her main research field is on optoelectronic applications (in terms of solar cells and photodetectors) of colloidal and organic–inorganic hybrid nanomaterials synthesized from bottom-up approaches.



Xinbo Yang is a professor in College of Energy, Soochow Institute for Energy and Materials InnovationS (SIEMIS), Soochow University, China. He received his Ph.D. degree in materials

science from the Chinese Academy of Sciences in 2010. He was a JSPS Fellow at Tohoku University, an ARENA Fellow at the Australian National University, and a research scientist at King Abdullah University of Science and Technology (KAUST) in Saudi Arabia. His current research interests include crystalline silicon solar cells, perovskite/silicon tandem solar cells, novel solar-cell materials and concepts, and atomic layer deposition of functional thin films.