Chinese university spin-offs spearhead the perovskite photovoltaic industrial revolution

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Perovskite solar cells (PSCs) have emerged as a promising alternative to conventional silicon-based solar cells due to their high efficiency, low manufacturing costs, and flexibility in application. The power conversion efficiency (PCE) of PSCs has seen a remarkable increase from a mere 3.8% in 2009[1] to over 26%[2] today, rivaling that of traditional silicon cells. Furthermore, by using the solar spectrum more effectively, perovskite/silicon tandem solar cells are frequently reported with a world record PCE of 33.9%,[2] exceeding the theoretical limit of any single-junction cell technology. This rapid progress is largely attributed to the relentless research and development efforts led by universities and research institutions all over the world. The commercialization of perovskite photovoltaic technology has made significant strides in recent years, spurred on by multiple scientific breakthroughs in the field.[2-5] In the past few years, China has experienced a surge in the number of university spin-offs entering the perovskite photovoltaic industry, marking a significant shift in the landscape of solar energy technology. These startups, often led by pioneering researchers and supported by academic institutions, are pushing the boundaries of large-area PSCs efficiency and commercial viability. This trend is not only reflects China's commitment to renewable energy but also highlights the unique role that high-tech university spin-offs play in the industry's evolution.

One such trailblazer is Mellow Energy, which emerged from the New Energy Technology Research Institute of Jinan University. Founded in August 2022 under the leadership of Professor Mai Yaohua, the company's focus on developing key technologies for large-area PSCs and modules has already yielded impressive results. By February 2023, their 100 MW module pilot line became operational, and by December 2023, they were producing modules with a certified power conversion efficiency (PCE) of 22.86%.

Another notable entrant is RenShine Solar, founded by Professor Hairen Tan from Nanjing University. Targeting industries such as electric vehicles, building-integrated photovoltaics (BIPV), and consumer electronics, RenShine Solar boasts a portfolio of independent intellectual property rights and patents covering the entire spectrum of perovskite solar cell technology. Their unique all-perovskite tandem cell technology promises to surpass the efficiency limits of single-junction cells while remaining compatibility with existing production processes.

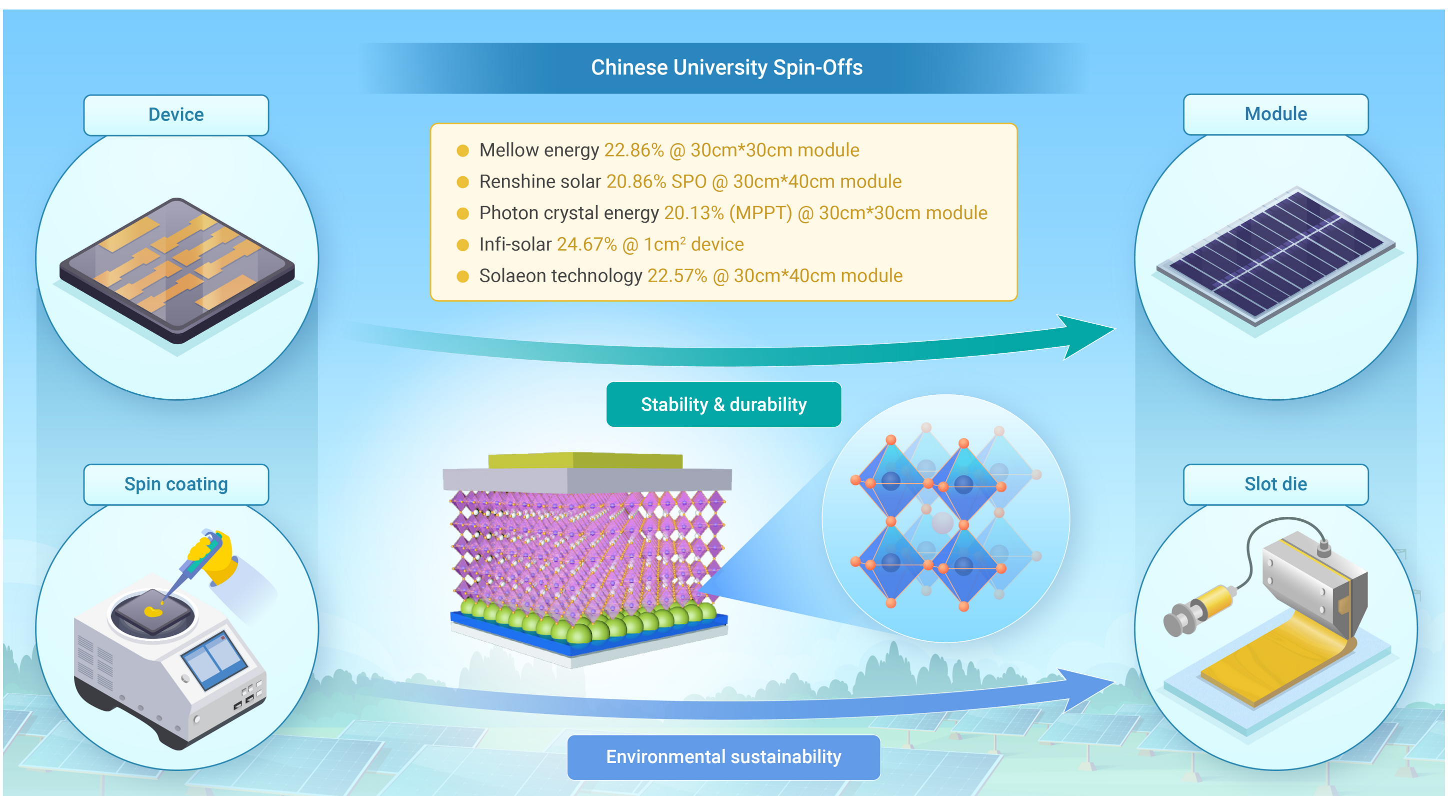

Figure 1. Chinese university spin-offs spearhead the perovskite photovoltaic industrial revolution.

Photon Crystal Energy Technology Co., Ltd. was founded by Professor Fuzhi Huang from Wuhan University of Technology, who has been focused on the research of high-efficiency, stable, large-area printable PSCs at lower cost for more than a decade, and well-known for his abundant experience in solar cell development and deep technology insights. The company's proprietary thin-film printing technology has produced large-area modules (815.9 cm^2) with industry-leading steady-state PCE of 20.13%.

There are More university spin-offs, recently. Infi-Solar was co-founded by Professor Yi Chenyi from Tsinghua University, successfully fabricate highly efficient 1 cm^2 device with a PCE of 24.67%. Professor Yang Xudong has been appointed as Chief Scientist by SolaEon Technology. Their 30cm*40cm module has reached a PCE of 21.63%. To understand the impact brought by the university spin-offs, we have interviewed their founders.

THE INTERVIEWS

Professor Mai told the author that he has a long pondered question. In 2007, China became the largest producer of solar cell components, and by 2013, it had turned into the country with the highest utilization of solar cells. Yet, despite this, why are numerous new companies emerging while many established ones are failing? What are the underlying causes of this constant flux? Professor Mai has observed that the current photovoltaic industry in China is facing several issues, with the lack of core technology in most companies being the most significant problem. But where is the core technology for perovskite photovoltaics being developed? Universities and research institutes provide an environment that fosters creativity and allows for long-term projects that may not yield immediate financial returns but are crucial for achieving breakthroughs. Experts have stated that the theoretical limit for the conversion efficiency of crystalline silicon solar cells is capped at 29.43%, a benchmark that the industry has repeatedly tried and failed to surpass over the years. In contrast, PSCs with a single-junction configuration have a theoretical efficiency ceiling of 33%, and the efficiency can soar up to 45% for tandem perovskite cells. Furthermore, perovskite materials are composed entirely of elements commonly found in nature, which means their large-scale production is not hindered by raw material constraints. "This is truly an uncharted territory; we have almost no mature experience to draw upon, and we must forge our own path," said Tan Hairen, Chairman of RenShine Solar and Professor at Nanjing University.

When asked about the inspiration behind transitioning from academia to founding a company focused on perovskite solar cell technology, Professor Huang highlighted the potential of perovskite photovoltaics to revolutionize the solar energy landscape and make solar power a truly clean energy source. He emphasized the need for more research talent and industry professionals specializing in perovskite technology, citing this as the driving force behind his decision to establish a technology company dedicated to accelerating the industrialization of PSCs. Reflecting on the influence of his academic background on his entrepreneurial approach, Professor Huang emphasized the importance of scientific rigor in operations and the focus on solid technical development.

THE PIVOTAL ROLES

The unique role of high-tech university spin-offs in the development of the perovskite photovoltaic industry cannot be overstated. These spin-offs benefit immensely from their direct access to cutting-edge technology developed within academic institutions. Universities and research institutes are often at the forefront of scientific discoveries, and spin-offs can leverage this proximity to adopt the latest innovations swiftly. This access allows them to integrate the latest advancements into their product development processes, ensuring that they remain at the cutting edge of technology.

Furthermore, the culture of innovation that permeates academic institutions significantly influences these spin-offs. Universities foster an environment where creativity and experimentation are encouraged, leading to groundbreaking research and novel solutions. This innovative culture is carried over to the spin-offs, where it drives their approach to problem-solving and product development. The ability to think outside the box and explore unconventional methods is a hallmark of these high-tech startups, enabling them to push the boundaries of what is possible with perovskite technology.

Moreover, the close collaboration between spin-offs and their parent universities provides a robust support system. Academic institutions often offer resources such as state-of-the-art laboratories, funding opportunities, and access to a network of experts in various fields. This support helps spin-offs overcome some of the challenges they face, such as scaling production and navigating complex intellectual property landscapes. Additionally, the entrepreneurial culture within these spin-offs attracts talented individuals who are passionate about making a tangible impact on the renewable energy sector. This influx of talent further strengthens the spin-offs' capabilities and drives their mission to advance perovskite photovoltaic technology.

THE MAIN CHALLENGES

However, these startups also face challenges when compared to established players in the field. They may lack the scale and resources to compete in manufacturing and distribution networks. Additionally, they must navigate the complex landscape of intellectual property and international regulations while ensuring financial sustainability. The primary challenges encountered in commercializing perovskite photovoltaic technology are three key areas: funding, talent acquisition, and technical development.

Funding: The commercialization of perovskite solar cell technology requires substantial financial investments, particularly for pilot line construction. Establishing a pilot production line is a capital-intensive process that involves significant expenditure on equipment, materials, and facilities. Securing adequate funding is often a major hurdle for university spin-offs, as they need to convince investors of the long-term viability and profitability of their technology. Without sufficient financial backing, these startups may struggle to scale their operations and bring their products to market.

Access to Talent: Another critical challenge is the acquisition of experienced professionals who specialize in perovskite production. The field of perovskite photovoltaics is relatively new, and there is a limited pool of experts with the necessary skills and knowledge. University spin-offs must compete with established companies to attract top talent, which can be particularly difficult given their limited resources. Additionally, these startups need to invest in training and development programs to build a workforce capable of handling the complexities of perovskite technology.

Technology Development: The path to mass production of PSCs is fraught with scientific and technical issues that must be addressed (Figure 1). Key challenges include improving the stability of perovskite materials, optimizing manufacturing processes for large-scale production, and ensuring the environmental sustainability. University spin-offs must engage in rigorous research and development to overcome these hurdles, often working closely with their academic partners to leverage the latest scientific advancements. Addressing these technical challenges is essential for achieving the reliability and performance standards required for commercial success.

Despite these challenges, high-tech university spin-offs are indispensable in the industrialization of perovskite photovoltaic technology. These spin-offs serve as a bridge between the laboratory and the marketplace, translating cutting-edge research into viable products and technologies. They are often at the forefront of innovation, pushing the limits of what's possible with PSCs, such as enhancing their efficiency and making them more commercially viable. The global competitiveness in science and technology industries is increasingly defined by the ability to integrate research findings into practical applications. The synergy between market forces, government recognition, and scientific research platforms is essential for fostering an ecosystem where innovation can thrive.

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G.Q. and Z. Y. Q. conducted an interview and wrote the manuscript.

DECLARATION OF INTERESTS

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