High performance solar cell technology with integrated nanoplasmonic thin film and thermal management systems

This project aims to develop a novel high-performance thermally-managed (TM) nanoplasmonic (NanoPlas) solar technology that solves the bottleneck efficiency drop when solar cells operate outdoors at elevated temperatures and eventually boost the efficiency of industrial thin-film glass solar cells. This will be achieved through the development of NanoPlas thin film technologies for reduced thermal absorption and thermal management systems for removing heat from the photovoltaic (PV) panels and thus maintaining an optimal power generation performance. The thermal management technology can be applied to other solar cells to significantly improve the energy yield.

In order to dramatically enhance the efficiencies of solar cells using NanoPlas solar technology, the project team has proposed a novel core-shell design plasmonic nanostructure, and demonstrated an efficiency of 13.2% in amorphous silicon (a-Si) solar cells and an efficiency of 14.2% in a-Si/perovskite tandem solar cells. Due to the utilisation of inexpensive aluminium-based materials, the integration of the plasmonic nanostructures does not increase the cost of PV cells. The cost of the NanoPlas a-Si technology is estimated to be dramatically lower than those of silicon wafer technology and CdTe technology which are dominating the current PV market. Moreover, the team has developed an ultimate a-Si solar panel with a pilot production scale size of 30 cm x 30 cm, which is a big step forward towards the emerging building-integrated photovoltaics (BIPV) technology commercialisation. Based on these achievements, pilot production lines and facilities of NanoPlas a-Si solar modules will be established in both RMIT University and Swinburne University of Technology in 2017.

At different stages of the project various outcomes are achieved, which can potentially lead to applications in a variety of industries including energy, manufacturing, materials and building constructions. These outcomes mainly include

(A) high efficiency NanoPlas a-Si solar cells/modules,

(B) high efficiency TM NanoPlas a-Si solar cells/modules,

(C) pilot plant and processes for manufacturing a-Si solar cells and

(D) thermal management devices.

The following table summarises the main outcomes and the path to impact from the project:

No	Project outcomes	End User	Uptake	Adoption/usage	Outcome	Impact
1	Patents on TM-NanoPlas technology	Solar industry	A company (Suntech Wuxi) has licenced the patent	The company uses the patent to manufactures the solar modules	More efficient and lower cost solar panels on the BIPV market	Solar energy more affordable; Climate change solution; Reduction on pollution
2	High efficiency NanoPlas a-Si solar cells/modules	Solar panel users	A building-related customer (RMIT Design Hub) plans to apply the collar cells/modules in buildings/	The building-related customer buys and uses the solar panel	Demonstration of more efficient and lower cost BIPV technology to public; Cheaper BIPV products with more energy efficient and environment friendly features	Solar energy more affordable; climate change solution; reduction on pollution.
3	High efficiency TM NanoPlas a-Si solar cells/modules	Solar panel users	A PV company (Sunman) uptakes the building-related technology and manufacture the building-related products	The customer buys and uses the BIPV solar panels	Cheaper building-related products with more energy efficient and environment friendly features	Solar energy more affordable; climate change solution; reduction on pollution.
4	Pilot production lines/facilities for manufacturing a-Si solar cells	Research institutions and industries	A company (SKY) uptakes the technology and manufacture the pilot program	Research institutions buy the BPIV solar cell manufacture equipment	Cheaper equipment for R&D of nanomaterial integrated functionalities; platforms for world-leading BIPV R&D	Australian green energy R&D improved; Solar energy more affordable
5	Thermal management devices	A range of industry users (solar and thermal energy, defence, spacecraft, automotive, electronics, coal plant, industrial processors, cooling instrument)	An application has been identified in CSIRO Energy for solar thermal energy. The aim is to licence the technology to a manufacturer of solar thermal power plants.	A new concept design for a receiver for concentrated solar thermal energy is developed. The company would manufacture high-efficiency solar receivers	A reduction in the cost of renewable solar thermal energy technology with better output stability compared to wind and PV	Increase energy yield for solar energy, better performance for devices and systems, therefore achieve better economic value and more reduced carbon footprint
6	Research and technological papers on breakthrough of TM-NanoPlas technology, the economics of cooling solar cells, and heat pipe based receivers for concentrated solar thermal energy,	Scientists and engineers!	A publisher publishes the papers	Researchers and engineers read the papers	Positive change in making solar cells with better efficiency and lower cost	Development of new methods to make better performance solar cells; solar energy more competent with other energy/sources