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## NANO MINERAL AS AN EFFICIENT SOLAR CELL

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### ABSTRACT

In this paper we discuss the use of nano sized Perovskite as an efficient solar cell. Perovskite is a calcium titanium oxide mineral composed of calcium titanate, with the chemical formula  $\text{CaTiO}_3$ . The study has obvious implications for green energy, but may also enable innovations in lighting. If a solar panel is made of nano perovskite crystals as a fancy slab of glass and light hits the crystal surface and gets absorbed, exciting electrons in the material. Those electrons travel easily through the crystal to electrical contacts on its underside, where they are collected in the form of electric current. Further, the sequence may reverse as power the slab with electricity, inject electrons, and release energy as light. We also present, how a nano-particle and highly porous conducting perovskite could be the best promising solar cell and how it can be synthesized by a simple in situ sol-gel derived carbon-templating process.

**Keywords:** Green energy, Nano Perovskite, solar cell, Carbon templating, Photoluminescence.

### Introduction:

A perovskite solar cell is a type of solar cell which includes a perovskite absorber, most commonly a hybrid organic-inorganic lead or tin halide-based material, as the light-harvesting active layer, which produces electricity from sunlight. Perovskite absorber materials such as methylammonium or formamidinium lead halide are extremely cheap to produce and simple to manufacture. Solar cell efficiencies of devices using these materials have increased from 3.8% in 2009 to 20.1% in 2014, making this the fastest-advancing solar technology to date. Their high efficiencies and cheap production costs make perovskite solar cells an extremely commercially attractive option, with start-up companies already promising modules on the market by 2017. A further increase in efficiency is anticipated as the underlying photo voltaic principles become better understood. Parallel to fundamental research, it is now necessary to develop suitable concepts for up scaling the cells in a cost effective and more efficient process.



Normally, the catalytic properties (chemical or electro-chemical) of perovskite are closely related with its surface area, which is determined mainly by the particle size of the perovskite. Nano-structured materials have received great attention from scientific and industrial communities due to their unique properties in physics and chemistry. As compared to the coarse-grained ones, nano particles not only possess higher specific surface area, but also have more significant surface phase in homogeneity, that may substantially improve the catalytic activity. Nano-particles can also reduce the sintering temperature obviously for pellet densification due to the high surface energy, which is beneficial for the application in efficient solar cell.

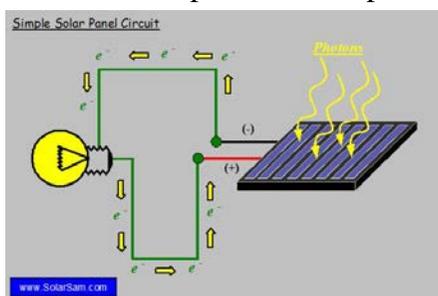
In this paper, we described a simple in situ sol-gel derived carbon templating process, which is capable of easily synthesizing the above three types of functional materials, i.e. nano perovskite particles, nano perovskite carbon composites, and highly porous perovskite sintering bodies. We could apply a mixed EDTA-citrate complexing process for the molecule level mixing of the raw materials. The solid precursor then obtained was calcined under oxygen deficient condition at high temperature to simultaneously convert the organic into carbon and create the perovskite oxide. Therefore, a nano perovskite-carbon composite could be obtained. By burning out the carbon with the following calcination under air at high temperature, pure phase nano-sized perovskite was obtained.

Nano Perovskite solar cells function efficiently in a number of somewhat different architectures depending either on the role of the nano perovskite material in the device, or the nature of the top and bottom electrode. Devices in which positive charges are extracted by the transparent bottom electrode (anode), can predominantly be divided into 'sensitized', where the nano perovskite functions mainly as a light absorber, and charge transport occurs in other materials, or 'thin-film', where most electron or hole transport occurs in the bulk of the nano perovskite itself. Similar to the sensitization in dye-sensitized solar cells, the nano perovskite material is coated onto a charge-conducting mesoporous scaffold most commonly  $\text{TiO}_2$  – as light-absorber. The photogenerated electrons are transferred from the nano porous perovskite layer to the mesoporous sensitized layer through which they are transported to the electrode and extracted into the circuit. The thin film solar cell architecture is based on the finding that nano perovskite materials can also act as highly efficient, ambipolar charge-conductor. After light absorption and the subsequent charge-generation, both negative and positive charge carrier are transported through the perovskite to charge selective contacts. Nano Perovskite solar cells emerged from the field of dye-sensitized solar cells, so the sensitized architecture was that initially used, but

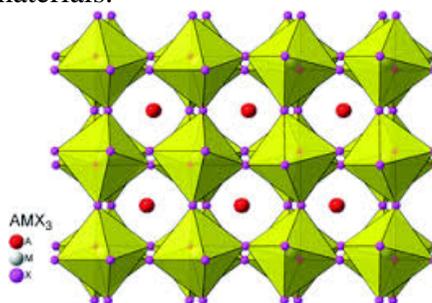
over time it has become apparent that they function well, if not ultimately better, in a thin-film architecture. Certainly, the aspect of UV-induced degradation in the sensitized architecture may be detrimental for the important aspect of long-term stability. The cells demonstrate little cell-to-cell variability, resulting in devices showing hysteresis-free photovoltaic response, which had been a fundamental bottleneck for stable operation of nano perovskite devices.

### Material and methods:

The name 'perovskite solar cell' is derived from the  $ABX_3$  crystal structure of the absorber materials, which is referred to as perovskite structure. The most commonly studied perovskite absorber is methyl ammonium lead trihalide ( $CH_3NH_3PbX_3$ , where X is a halogen ion such as  $I^-$ ,  $Br^-$ ,  $Cl^-$ ), with a band gap between 2.3 eV and 1.57 eV depending on halide content. Formamidinium lead trihalide ( $H_2NCH_2NH_3PbX_3$ ) is a recently studied newer material which shows promise, with a band gap between 2.23 eV and 1.48 eV. This minimum band gap is closer to the optimal for a single-junction cell than methyl ammonium lead trihalide, so it should be capable of higher efficiencies. A common concern is the inclusion of lead as component of the perovskite materials.



**Figure 1.** Schematic diagram of solar panel circuit

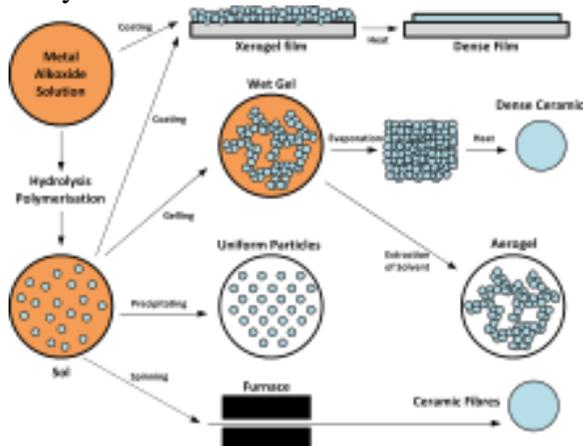


**Figure 2.** Generalized structure of a Perovskite solar cell

**Carbon templating process:** Analytical reagents of lanthanum nitrate, strontium nitrate, cobalt nitrate, iron nitrate and  $Mn(CH_3COO)_2$  were used as the starting materials for the synthesis of LSCF and LSM. The synthesis of LSCF, as an example, was described as follows. Stoichiometric amounts of lanthanum nitrate, strontium nitrate, cobalt nitrate, and iron nitrate were mixed into an aqueous solution. Necessary amount of  $EDTA-NH_3 \cdot H_2O$  was added to the solution. After stirring under heating for a couple of minutes, citric acid solution was then added and the mole ratio of metal ions: EDTA: citric acid:  $NH_3 \cdot H_2O$  was kept at 1:1:2:10. The solution was continuously heated at 80–100°C under stirring until a transparent gel was obtained, which

was heated at 250° C in an electrical oven for solidification. The as-obtained solid precursor was then calcined at high temperatures under oxygen deficient condition for various times. For this calcination, the furnace was pre-heated up to the aimed temperature before the solid precursor within an enclosed ceramic crucible was put in. The sample was withdrawn from the furnace to the ambient atmosphere when the aimed calcined time was reached. Some of the obtained powders were further calcined under open air at high temperature to result in the pure perovskite powder. For the preparation of porous perovskite, the obtained carbon-templated powders were formed into pellets, which were then calcined at 1000° C to form highly porous sintering bodies. A heating and cooling rate of 5° C min<sup>-1</sup> was applied in this case.

**In-Situ Solgel method:** In this spin coated or exfoliated lead halide is annealed in the presence of methylammonium iodide vapor at a temperature of around 150°C This technique holds an advantage over solution processing, as it opens up the possibility for multi-stacked thin films over larger areas. This could be applicable for the production of multi-junction cells. Additionally, vapor deposited techniques result in less thickness variation than simple solution processed layers. However, both techniques can result in planar thin film layers or for use in mesoscopic designs, such as coatings on a metal oxide scaffold. Such a design is common for current nano perovskite or dye-sensitized solar cells.



**Figure 3.** Schematic representation of the different stages and routes of the sol-gel technology.

### **Results and discussion:**

As mentioned previously, the preparation of carbon supported perovskite or perovskite-carbon composite is an effective way to increase



the electrode performance due to the increase in the surface area of the electrocatalyst (perovskite). The porous sintering body was constructed from nano particle with a particle size of 10–20 nm, which ensured a high surface area for oxygen surface activation. Furthermore, it shows that the particles attached to each other firmly due to the high calcination temperature (1000°C) was beneficial in reducing the interfacial polarization resistance for oxygen transportation. The high porosity and high surface area make the current in situ carbon templating process very promising for the preparation of porous electrode for functional application. In general Solar cells work by converting photons of sunlight into an electric current that moves between two electrodes. Silicon solar cells generate electricity by absorbing photons of visible and infrared light, while these nano perovskite cells can harvest only the visible part of the solar spectrum where the photons have more energy. Absorbing the high-energy part of the spectrum allows nano perovskite solar cells to generate more power per photon of visible light than perovskite cells. Nano porous Perovskite for their ability to absorb light in the ultraviolet-visible spectrum, their luminescence and electrical conductivity and their desirable properties for photovoltaic applications. Preparing perovskite as small nanoparticles (with a diameter of less than ten nanometres) allows them to disperse in a non-aqueous medium, which facilitates their processing and, thereby, their future use in solar cells and luminescent materials.

### ***Conclusions:***

One big challenge for nano perovskite solar cells is the aspect of short-term and long-term stability. The water-solubility of the organic constituent of the absorber material make devices highly prone to rapid degradation in moist environments. Encapsulating the carbonized nano perovskite absorber with out a composite of carbon nanotubes and an inert polymer matrix has to be demonstrated to successfully prevent the immediate degradation of the material when exposed to moist ambient air at elevated temperatures. However, no long term studies and comprehensive encapsulation techniques have yet been demonstrated for perovskite solar cells. Beside moisture instability, it has also been shown that the embodiment of devices in which a mesoporous TiO<sub>2</sub> layer is sensitized with the perovskite absorber exhibits UV light induced instability. The cause for the observed decline in device performance of those solar cells is linked to the interaction between photogenerated holes inside the TiO<sub>2</sub> and oxygen radicals on the surface of TiO<sub>2</sub>.



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