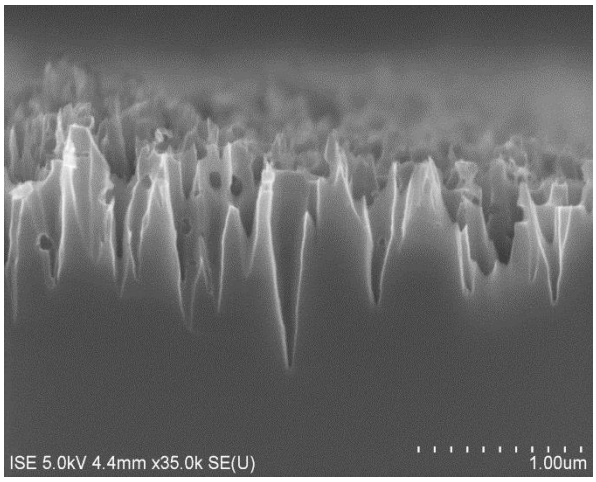
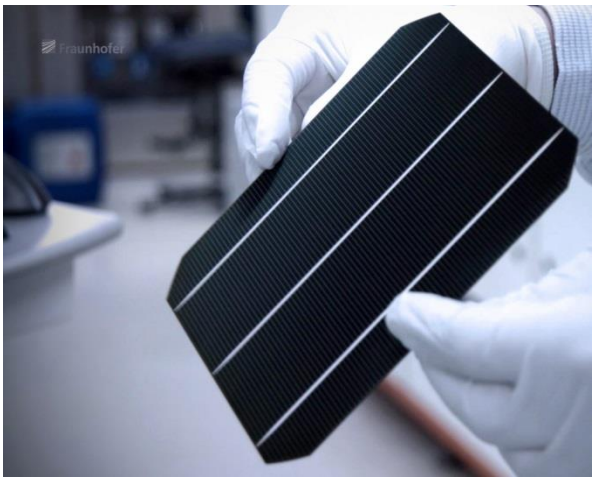
Development and characterization of maskless dry texturing method for crystalline silicon solar cell (Ref: ISE-2017-376)

A master thesis in physics, chemistry, electrical engineering, microsystem technology, nanotechnology, materials science or similar is offered within the division, "Photovoltaics" in the group "Plasma Technology" of the Fraunhofer Institute for Solar Energy Systems (ISE) in Freiburg, Germany.



SEM image of Si surface after dry F_2 etching



Solar cell with anti-reflection coating (ARC) after screen-printing the contacts

Motivation

Alkaline wet-chemical etching is the current method used to reduce surface reflection in crystalline silicon solar cells and to achieve increased light trapping properties. However, this process is strongly dependent on features such as crystal orientation or grain boundaries, especially in case of multicrystalline wafers and long process times. Alternative acidic textures are highly isotropic if performed without masking and provide a comparatively high surface reflection. For this reason, dry etching processes were investigated intensively as an alternative to wet-chemical processes. Despite good results in the laboratory, the dry etching process in the manufacturing lines of the industry has not yet been achieved, which is on the one hand due to the tightened regulations concerning the reduction of the emissions of fluorine - containing greenhouse gases (e.g., Kyoto Protocol and EC regulation no. 842/2006) on the other hand with the initially high cost of plasma and vacuum equipment.

Objective

The project goal is to further develop a novel dry process alternative for the PV applications that will eliminate the need of high water consumption and prevent the emission of high global warming potential (GWP) gases in the atmosphere. A dry and atmospheric pressure silicon etching technology using F_2 gas has been already developed in our institute with our industrial partners, and this technology would be further investigated to achieve precise texture and etching processes requirements in the solar cell manufacturing. Si etches spontaneously in the presence of F_2 gas. The reaction product is Si_xF_y. Thermal activation of F_2 gives an opportunity to etch/texture Si without any plasma excitation. This gives an advantage to texture silicon without any need of plasma while having a potential to increase the efficiency of a solar cell. The work is planned to be performed in the laboratories of Fraunhofer ISE in collaboration with industrial partners.

The duration of the masters thesis is a minimum of 6 months (with earliest possible start in March 2018).

Requirements

The thesis deals with both solid state physics and etching technology in the field of industrial-oriented solar cell research. The topic can be adapted according to the size of the work and personal interest. The topic includes:

- Creation and execution of statistical test plans on the etching tool
- Geometrical, optical and electrical characterization of the textured wafer surface
- Modeling the etching phenomena of silicon by fluoride atoms
- Examination of the passivation behavior of different passivation layers on textured surfaces surface
- Integration of the process into the PERC solar cell structure; production of solar cells and comparison with the reference of the wet-chemical process of a pilot line at Fraunhofer ISE.

Conditions

- Study at an university in the area of physics/chemistry/electrical engineering/microsystem technology/nanotechnology/material sciences or similar
- Enthusiasm in experimental work and in the understanding of complex physical/chemical processes
- Self-motivation and teamwork
- Good written and spoken knowledge in English. German language skills help, but are not obligatory.

About Fraunhofer ISE in Freiburg

The Fraunhofer Institute for Solar Energy Systems ISE is the largest solar energy research institute in Europe. With currently about 1100 employees, it conducts applied research for the technical use of solar energy and develops materials, systems and processes for a sustainable energy supply. To this purpose, the Institute develops systems, components, materials and processes in the areas of the thermal use of solar energy, solar building, solar cells, electrical power supplies, chemical energy conversion, energy storage and the rational use of energy. The Institute's work ranges from fundamental scientific research relating to solar energy applications, through the development of production technology and prototypes, to the construction of demonstration systems. The Institute plans, advises and provides know-how and technical facilities as services.

About the city

Freiburg - an extreme south-west German city, stands near to the German-French-Swiss borderline. Minster, small streams, green hills - you will find all of this and much more here in this city. Go on a tour of discovery through the sunny city and let the pleasant Baden way of life combined with the flair of an international university and ecological flagship city work its magic on you. Freiburg gives you a warm welcome. See more info on www.freiburg.de.

Contact

Dr. Bishal Kafle
Division Photovoltaics
Fraunhofer Institute for Solar Energy System ISE
Heidenhofstrasse 2, D-79110 Freiburg, Germany
Telephone: +49 (0)761 4588 5499
Email: bishal.kafle@ise.fraunhofer.de