APERIDODIC SOLAR CELLS ENHANCING THE LIGHT ABSORPTION IN THIN FILM PATTERNED WITH QUASICRYSTALS

LENS, European Laboratory for non-linear spectroscopy · Vitantonio Matarazzo
KTH, Royal Institute of Technology · Reza Sanatinia
ENEL GREEN POWER + PROPOSED SPIN-OFF LAMBDA-ENERGY

Project objectives

The aim of this project is to demonstrate the potential advantages of using a-periodic structures (e.g. a photonic quasi-crystal) to enhance light absorption in thin film solar cells.

Project results

LENS has focused on 3D FDTD method for optimizing quasi periodic structures to enhance absorption in thin film geometries (~ 200-300 nm thick). These designs have been made assuming ideal fabrication conditions, and may have to be refined. The designs are made for three different material systems: InP based materials, crystalline silicon and amorphous silicon. In the simulation we have taken in account the material dispersion fitting the dispersion function of the material. Three different aperiodic geometries have been simulated: Fibonacci, Thue-Morse and Rudin-Shapiro. These structures are very interesting because they are in between the periodic and random structure. They can be classified according to the spectral measures of their spatial Fourier transform and are characterized by quasiperiodic (Fibonacci), singular continuous (Thue-Morse) and absolutely continuous (Rudin-Shapiro) Fourier spectra. They exhibit both a well-defined band-gap, as periodic structure, and localized modes (critical modes), as random structure. In particular the critical modes decay weaker than exponentially (Anderson modes in random structure) and possess a rich self-similar structure. These modes are very important because the optical mechanism that determines an increase of the absorption of the incident light is the coupling between the solar radiation and the guided modes of the patterned slab.

The technology is not straight-forward and requires several materials (deposition) and associated process technologies. As a starting point, based on KTH's expertise in III-V nano-fabrication, thin photonic crystal membranes in InP-based material less than 300 nm thick was developed at KTH. The fabrication involves E-beam lithography, different pattern transfer steps and selective wet etching to obtain membranes. Fabrication of similar structures in Si (a-Si and SOI) has been started, but requires additional effort to optimize e-beam patterning and etching of nano-holes in Si with smooth side-walls.

Conclusion

A set of absorption enhancing a-periodic structures in thin films of different materials have been achieved by LENS. The development of the technologies at KTH has progressed sufficiently and the realization of the proposed a-periodic structures is feasible.

The project will be continued, and during the next six months KTH will fabricate the designed structures in InP and Si, and LENS will characterize the samples. The efforts are expected to converge to show the potential application of such a-periodic structures for enhanced absorption in thin film solar cells.