SUPERQUADRIC SHAPED NANO-PILLARS FOR IMPROVED ELECTROMAGNETIC ABSORPTION IN NANO-STRUCTURED SOLAR CELLS

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Increasing the absorption efficiency is one of the key tasks towards maximizing the overall solar cell efficiency which is a product of absorption efficiency, carrier generation efficiency, and carrier extraction efficiency. It has been shown that nano-pillar array photovoltaic (PV) solar cells exhibit increased electromagnetic absorption in comparison to conventional flat solar cells. Furthermore, shaped nano-pillars, such as nano-conic and nano-pyramid arrays have better broadband properties than nano-pillar arrays. This can be potentially attributed to better matching between free-space region and the nano-structured array region, reducing inherent reflection from the surface.

Although desirable, these canonical shapes may not be feasible in their true form due to fabrication limitations. Current techniques of fabrication allows the use of nano-pillars as starting structures with modifications done afterwards to resemble conic or pyramidal shapes, however, these structures fail to match their canonical forms. Often, structures fabricated using such techniques will have a shape somewhere between a complete nano-pillar and a nano-pyramid or nan-ocone. To understand the electromagnetic performance for these intermediate structures, it was necessary to identify a series of shapes that could closely represent them utilizing an appropriate function.

It was determined that a superquadric function could serve this purpose. This function, applied to the edge of the nano-pillars, allows the shape of the nano-pillar to be modeled anywhere between a pure nano-pillar and a pure cone (or pyramid). This modeling allows for full-wave analysis of more realistic shapes that are more likely able to be fabricated. This presentation will investigate different superquadric nano-structured PV (photo voltaic) arrays for their reflection and absorption properties. Different shapes generated using the superquadric function will be evaluated for their optical properties ranging from hexagonal nano-pillar to hexagonal nano-pyramid. The elliptical superquadric nano-structures will be used for different parametric studies including height, radius, and incident angle variation. Novel representative results will be presented to highlight advantages and disadvantages of various configurations and potentially providing effective guidelines on the fabrication processes and their impact on the overall performance of nano-pillars.