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Photoabsorption Efficiency Improvement for Photovoltaic Solar Cells by Using the Honeycomb Nanostructures

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Abstract. In this paper we propose a designs of solar cells based on III-V semiconductors which can deliver more efficient, less expensive solar cells. Recently proposed approaches to enhance the efficiency utilize the novel III-V nanomaterials containing quantum dots, and new concepts like intermediate bandgap quantum dot based solar cells promise the efficiency over 50% [1]. Needs for thin flexible space solar cells are supposed to be fulfilled with Inverted Metamorphic Multijunction (IMM) solar [2]. In this paper we consider the alternative design of flexible solar cells, which is based on a honeycomb nanostructure consisting of embedded semiconductor pillars in a flexible film [3]. Such nanostructures are flexible and solar cells therefore are suitable for wider range of applications compared to ones with solid panel design, and are less expensive due to the smaller fraction of the active semiconductor material. However this kind of design may reduce the efficiency of the solar cell due to the volume filling factor..

Key words

Nanostructured, photovoltaic cell, flexible, photoabsorption..

1. Introduction

In this paper we propose a designs of solar cells based on III-V semiconductors which can deliver more efficient, less expensive solar cells. Recently proposed approaches to enhance the efficiency utilize the novel III-V nanomaterials containing quantum dots, and new concepts like intermediate bandgap quantum dot based solar cells promise the efficiency over 50% [1]. Needs for thin flexible space solar cells are supposed to be fulfilled with Inverted Metamorphic Multijunction (IMM) solar [2]. In this paper we consider the alternative design of flexible solar cells which is based on a honeycomb nanostructure consisting of embedded semiconductor pillars in a flexible film [3]. Such nanostructures are flexible and solar cells therefore are suitable for wider range of applications compared to ones with solid panel design, and are less expensive due to the smaller fraction of the active semiconductor material. However this kind of design may reduce the efficiency of the solar cell due to the volume filling factor.

2. Proposed Approach

We intend to show that the proposed nanostructured solar cell have the same efficiency as monolithic cells, while contain the smaller fraction of the active semiconductor material.

We present the models and simulation results that show that the filling factor does not limit the efficiency of such solar cell, in contradiction with the common sense approach, is not valid for such nanostructures. We provide the detailed analysis of such multiscale models (nanostructure feature size is much less than light wavelength), show that the absorption efficiency is more than 90%, and that such nanostructures also work as concentrators, comparable to Goetzberg et al[4].
There are several parameters that describe the efficiency of a solar cell. Usually a recombination rate and a carrier transport have to be calculated in order to obtain a power efficiency of the device or external quantum efficiency. We are primarily interested in the absorption of photons and showing that the efficiency of photoabsorption is not necessarily proportional to the volume filling factor. We will compare a quantum efficiency of the bulk semiconductor to the efficiency of composite structure.

Honeycomb photovoltaic nanostructures, consisting of embedded semiconductor rods in a flexible film, are proposed for flexible solar cell design to make the devices resistant against thermal and mechanical stresses, therefore suitable for wider range of applications compared to ones with solid panel design.. However this may reduce the efficiency of the solar cell due to the