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Fluorescent silicon carbide materials for white LEDs and photovoltaics

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ABSTRACT

Energy efficient materials solutions will be key figures in progressive energy saving applications. We explore a materials growth concept of fluorescent wide bandgap semiconductors for white and infrared LEDs as well as solar cells. This is an emerging scientific field which has not previously been explored.

The applications include a white LED for general lighting in which the conversion is based on the semiconductor instead of using phosphors. The result is an LED technology which does not need rare earth metals and has a pure white light. In efficient fluorescent materials, the absorption may be very efficient. This leads to the concept of using wide bandgap fluorescent materials for solar cells. The efficiency is increased by introducing certain dopants, so that solar absorption is increased in a single material. This is an advantage to multijunction solar cells where there are electron losses at each junction.

We have applied novel methods to produce the fluorescent materials [1]. Thick doped silicon carbide layers may be grown to produce a voluminous medium from which the dopants act to produce a donor to acceptor pair recombination mechanism. In hexagonal silicon carbide the luminescence appears in the visible region which is used to produce a white LED with pure white light without need of phosphors [2]. The cubic silicon carbide polytype is challenging to master, and we have explored the growth of this crystal structure. It has a lower bandgap, and by a similar doping concept the luminescence appears in the infrared region in a broad range from 700 to 1100 nm. This potentially can be used to develop an infrared LED for de-icing in wind power and airplanes, or medical applications. Further on, a very efficient solar cell material can be investigated by studying the impurity effect in cubic silicon carbide. The impurity photovoltaic effect could lead to devices with efficiencies comparable to those of tandem systems, and could open a new road for very-high-efficiency solar cells. Such high performance can be reached only if the host material has a large energy gap, like cubic silicon carbide [3,4].

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