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Novel Architectures Combining a Luminescent Down-Shifting Layer and a 2D Photonic Structure for Enhanced Light Management

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In crystalline silicon-based solar cells, a substantial part of the energy losses is related to the carriers' thermalization in the UV-blue range. This issue can be partially circumvented by a down-shifting process inside a luminescent rare-earth (RE) doped thin layer. However, due to the low absorption cross-section of the RE ions, the efficiency of the converting layer needs to be increased. In this study, we introduce a new concept which combines a rare-earth doped thin layer (Y_2O_3: Eu^{3+}) with a 2D photonic crystal (SiN_x), in order to take control of the frequency conversion process. A Y_2O_3:Eu^{3+} 100 nm thick layer was first deposited by Pulsed Laser Deposition. Above this converter layer, a SiN_x thin film was then deposited and periodically patterned using laser interference lithography and reactive ion etching, to ensure an exaltation of the guided electromagnetic field inside the luminescent layer. This nanophotonic structure was designed and optimized using RCWA simulation in order to enhance separately absorption and emission of the rare-earth layer or both of them at the same time.

In this communication, we will discuss on the design, fabrication and measurements performed on these new architecture enabling the control of light-matter interaction. We will show that a substantial enhancement of the conversion yield was achieved, which could pave the way to the development of more efficient photovoltaic devices.

Key words: pulsed laser deposition, laser interference lithography, luminescence, down-shifting, rare-earth, photonic crystals, photovoltaics