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Er-based materials for Si microphotonics

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ABSTRACT

We have investigated the role of the Si excess on the photoluminescence properties of Er-doped Si nanoclusters (Si nc). We demonstrate that the Si excess has two competing roles: when agglomerated to form Si nc it enhances the Er excitation efficiency but it also introduces new non-radiative decay channels. When Er is excited through an energy transfer from Si nc, the beneficial effect on the enhanced excitation efficiency prevails and the Er emission increases with increasing Si content. The luminescence quenching processes limiting quantum efficiency in Er-doped Si nc light emitting devices are investigated and identified. It is found that carrier injection, while needed to excite Er ions through electron–hole recombination, at the same time produces an efficient non-radiative Auger de-excitation with trapped carriers. The maximum excited Er fraction in this system is only of the order of percent. In order to increase the concentration of excited Er ions, a different approach based on Er silicate thin films has been explored. Under proper annealing conditions, an efficient luminescence at 1535 nm is found and all the Er ions in the material are optically active. The possibility to efficiently excite Er ions also through electron–hole mediated processes is demonstrated in nanometer-scale Er–Si–O/Si multilayers.