Increasing Gain in p-modulation doped InAs Quantum Dot Lasers

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Reliable and efficient electrically-pumped silicon-based lasers are currently required for silicon photonics. Compound semiconductor laser structures epitaxially grown on silicon would be the ideal solution for large scale manufacturing, providing performance issues can be addressed. To date the best results have been achieved with InAs quantum dots grown on a GaAs lattice constant compound semiconductor structure all grown on silicon substrates. This is because the quantum dot active region is relatively insensitive to a small number of defects but it suffers from relatively low levels of modal gain. We have previously shown that low optical loss QD structures grown on silicon can have excellent performance with long lifetimes and now want to maximise optical gain obtainable from the dots to extend this good performance to shorter lasers using modulation p-doping.

Using NextNano software we perform a study of the optimum position and doping density of Be acceptors placed within the active region of multilayer quantum dot lasers. We grow a number of these designs on GaAs substrates to assess the practical outcomes. Using 7-layer quantum dot materials with optimised dot density per layer and size distribution, measured by Atomic Force Microscopy and photoluminescence respectively, we achieve high gain structures with ground state lasing at room temperature for uncoated facet lasers with cavity length as short as 330 um.

Short abstract:

We perform a computational and experimental study of InAs Quantum Dot lasers on GaAs substrates with the intention of maximising the gain to understand and improve the performance of such devices for growth on silicon. Optimised parameters include the position and level of modulation p-doping, the dot density and the size distribution and result in ground state lasing at room temperature for uncoated facet Fabry-Perot lasers as short as 330 um.