Quantum Dot Lasers for Silicon Photonics by Heteroepitaxy

Alan Y. Liu[b*], Arthur C. Gossard [a,b] and John E. Bowers [a,b],
[a] *Electrical and Computer Engineering, University of California Santa Barbara, USA*
[b] *Materials Department, University of California Santa Barbara, USA*
* Corresponding author: ayliu01@umail.ucsb.edu

InAs quantum dot lasers are an attractive light source to meet low power consumption and athermal performance demands for silicon photonics devices/packages, having demonstrated the lowest threshold current densities and highest lasing temperatures of any semiconductor laser [1-2]. For integration onto silicon, both wafer bonding and direct epitaxial growth approaches have been explored [3-5]. In the case of direct growth, carrier localization from individual quantum dots along with a low transparency current density dramatically reduces the total non-radiative recombination rate for quantum dot lasers epitaxially grown on silicon relative to quantum wells [2-3].

In this talk, we will review recent progress on 1.3 μm InAs/GaAs lasers directly grown on silicon substrates by molecular beam epitaxy. A direct comparison of such lasers to $In_{0.2}Ga_{0.8}As$/GaAs quantum well lasers also grown on silicon substrates with similar dislocation densities will be presented. As will be shown, despite comparable performance between the two types of active regions when grown on native GaAs substrates, quantum dot active regions significantly outperform their quantum well counterparts when grown on silicon substrates. Record continuous-wave output powers and lasing temperatures among lasers on silicon have been achieved with the aforementioned quantum dots lasers, despite very high residual dislocation densities ($\sim 10^8$ cm^{-2}) within the laser structure from the III-V on silicon epitaxy [5].

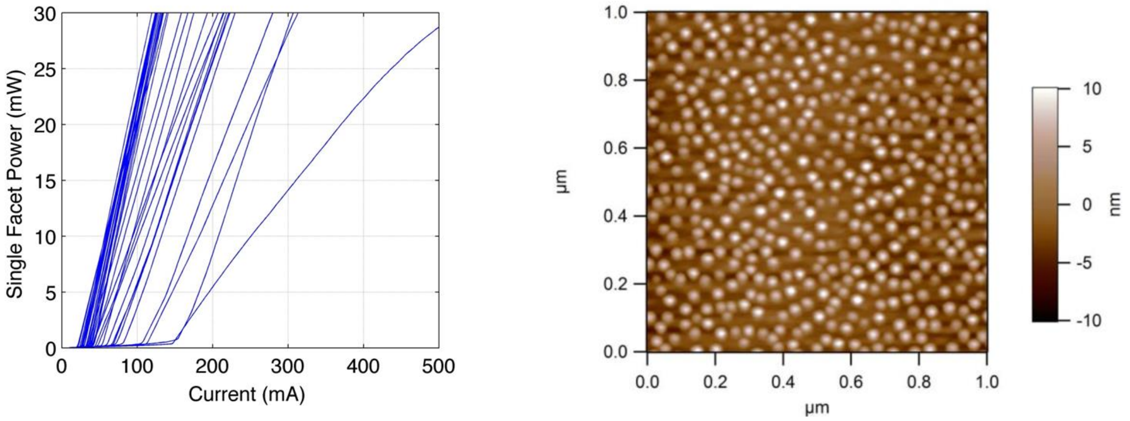

Fig 1. Left: Room temperature continuous wave LI curves of various InAs quantum dot lasers on silicon from a single 1130 μm long bar. HR coating was applied to one facet. Right: 1x1 μm^2 AFM scan of uncapped InAs/GaAs quantum dots on silicon.

References:
[1] T. Kageyama *et al.*, The European Conference on Lasers and Electro-Optics, (Optical Society of America, Germany, 2011).
[2] B. Dieter and U. W. Pohl, Mater. Today **14**, 388 (2011).
[3] K. Tanabe, K. Watanabe, and Y. Arakawa, Sci. Rep. **2**, 349 (2012).
[4] A. D. Lee, Q. Jiang, M. Tang, Y. Zhang, A. J. Seeds, and H. Liu, IEEE J. Sel. Top. Quantum Electron. **19**, 1901107 (2013).
[5] A. Y. Liu, C. Zhang, J. Norman, A. Snyder, D. Lubyshev, J. M. Fastenau, A. W. Liu, A. C. Gossard, and J. E. Bowers, Appl. Phys. Lett. **104**, 041104 (2014)