

Self-assembled semiconductor microtube optical resonators

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Background and Significance Micro-scale lasers can be more efficient, faster and more reliable than standard edge-emitting laser diodes. Typical microscopic lasers are fabricated with a top-down process, rather than bottom-up self assembly. A mixed process, based on optical lithography and self-assembly of strained semiconductor bilayers promises to bring the advantages of self-assembly (large numbers of small scale devices and ease of fabrication) to the fabrication of microscopic lasers which could be integrated into silicon platforms. These microtube devices could also be used as refractometric sensors.

Methodology The microtubes are based on coherently strained, epitaxially grown, semiconductor bilayers which roll upon themselves when released from their substrate and contain self-assembled InAs quantum dots as light emitters (Fig. 1(a)). We have fabricated microtubes using two different material systems for the bilayers: GaAs/InGaAs and InGaAsP/InP. The fabrication process involves two main steps (sketched in Fig. 1(b)). First, a U-shaped mesa is patterned in the sample in order to create a region that will be free-standing (and thus reduce leakage of light onto the substrate and result in better optical quality). Then, this mesa is carefully released from the substrate using a selective sacrificial etch (in the case of the GaAs/InGaAs microtubes there is an AlGaAs sacrificial layer, and no such layer is needed for the InGaAsP/InP microtubes). The final result is a free-standing rolled-up microtube, connected to the substrate by the two supporting side pieces (Fig. 1(c)).

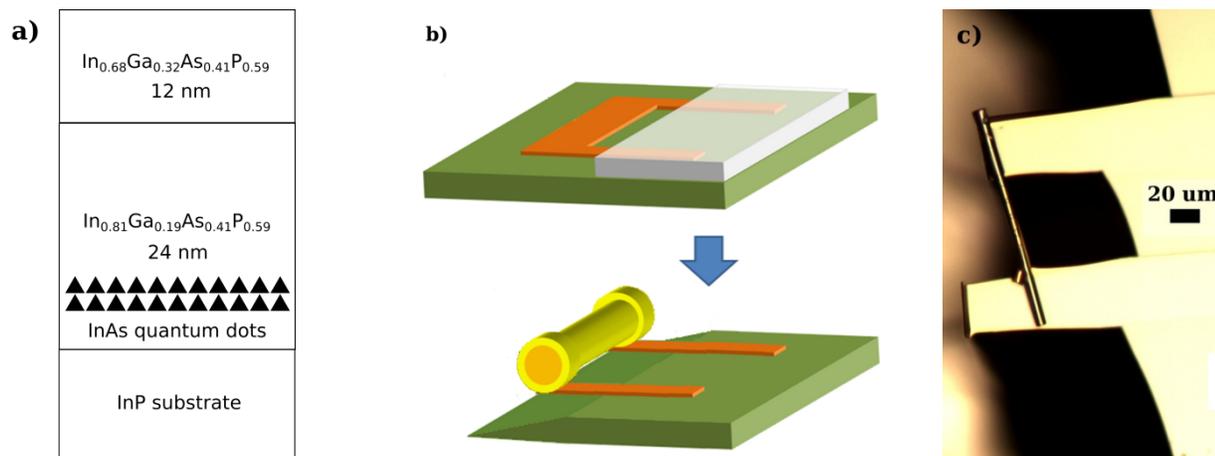


Figure 1: (a) Bilayer composition in the InGaAsP/InP material system. The top layer is under tensile strain. b) Sketch of the fabrication process for the free-standing microtubes using the InGaAsP/InP material system. c) Optical microscopy image of a fabricated InGaAsP tube, showing the optically isolated free-standing part at the center.

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Selected publications Z. Mi *et al*, **Self-organized InAs quantum dot tube lasers and integrated optoelectronics on Si** *SPIE Proceedings* **7943**, 79431C (2011)

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