# Controlling dislocation formation and dynamics in GaAs-based films on silicon with indium alloying

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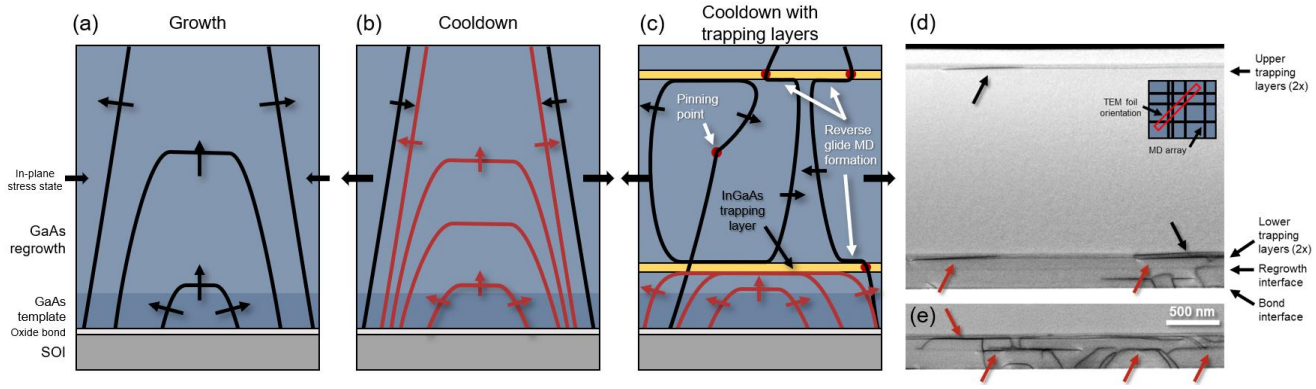


**Figure 1.** Confining dislocations with InGaAs trapping layers (TLs) in GaAs-based regrowth of GaAs bonded on silicon. **(a)** During homoepitaxial GaAs regrowth on the GaAs template with no TLs, the GaAs template begins compressive stressed due to thermal expansion mismatch with the silicon (SOI) substrate. As critical thickness is crossed, a modest number of dislocations nucleate to relax the compressive stress. **(b)** During cooldown, the relaxed film begins building tensile stress. Under these conditions, a large number of dislocations nucleate in attempt to relax the stress. **(c)** Growing a compressive stressed $In_{0.15}Ga_{0.85}As$ TL near the bottom of the film blocks these dislocations from propagating to the upper layers of the film since they are repelled by this oppositely stressed layer. Adding this layer alone achieves a ~10-20× reduction in surface threading dislocation density. Less obvious, inserting a second TL nearer to the surface reduces dislocation density by a further 2× by inhibiting dislocation multiplication mechanisms, one of which, the spiral source, is depicted on the left side of (c). This results in misfit dislocations forming below the upper TL and above the lower TL. Such misfits can also form by reverse glide of threading dislocations (right side of (c)), but this does not affect surface threading dislocation density. **(d)** Cross sectional STEM of a structure similar to (c) shows misfit dislocations (red arrows) blocked below the lower TLs. Misfit dislocations appear as short lateral segments due to the orientation of the TEM foil to the misfit array, indicated by the inset. We also see misfit dislocations (black arrows) on inner faces of the upper and lower TLs, which likely form by impeded multiplication processes described in (c). **(e)** Additional examples of dislocation trapping below the lower TLs.

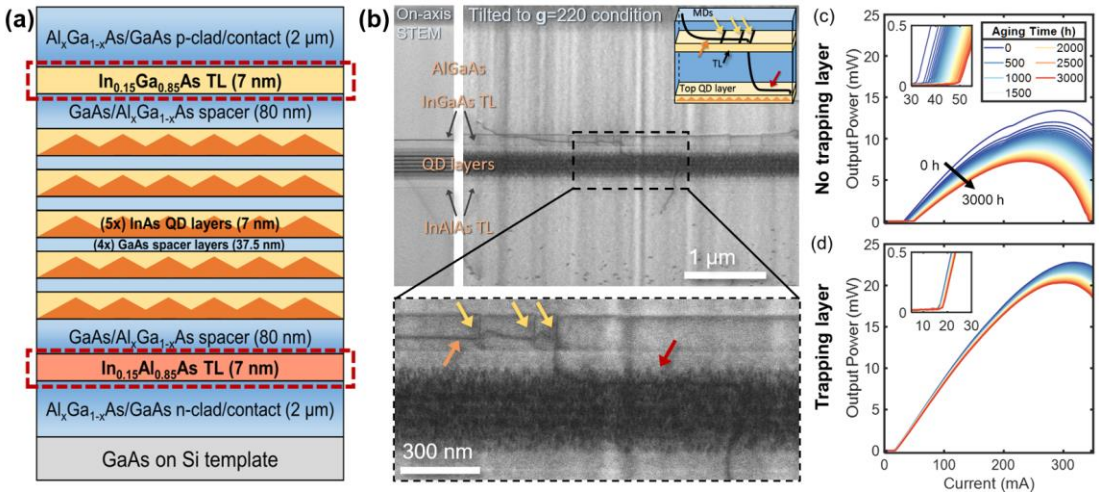


**Figure 2.** Strained indium-alloyed layers as dislocation TLs in laser structures. **(a)** Illustration of an InAs QD laser structure modified to include indium-containing TLs to hold misfit dislocations away from the active region. **(b)** Cross sectional STEM images taken both on zone (left)—showing the 5 QD layers and the two TLs—and tilted to the **g=220** condition to give a projected view of the TLs. This reveals misfit dislocations running along (orange arrow) and cutting across (yellow arrows) the top of the upper TL, which is shown magnified for the boxed region and illustrated in the inset. The red arrow indicates a rare instance of the TL failing to hold a segment of misfit dislocation away from the active region. No instances of misfits at the lower TL are visible here but do exist elsewhere. **(c)** A QD laser on silicon with no TLs exhibits relatively rapid degradation after 3000 h of 60 °C aging at twice its initial threshold current. **(d)** The TL laser under similar aging conditions shows a dramatic reduction in the rate of degradation. Insets show a magnified view of threshold current change.