Coalescence Phenomena in Narrow-Angle Stripe Epitaxial Lateral Overgrown InP by MOCVD

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The primary goals in Epitaxial Lateral Overgrowth (ELO) of one material over another are a) defect reduction and b) maximizing the amount of lateral growth vs. vertical growth. However, unless the material is very insensitive to defect concentrations, the usable size of even the largest field of ELO material will be cut in half by a coalescence front that creates defects when the two lateral growth wings converge. Work by Olsson et.al. has shown promising Photoluminescence (PL) results where HVPE-grown ELO InP on Si appears to have coalesced with a reduced number of recombination center defects[1]. One aspect of their approach involves using the so-called zipper effect[2] which relies on the idea that the coalescence defects can be eliminated if the convergence of two lateral growth fronts can be arranged to occur at certain optimal angles. This is intended to avoid simultaneous convergence at multiple points along the convergence front, as experienced by parallel lines. We have investigated the zipper effect in ELO InP by MOCVD using various growth conditions on paired ELO stripes with very narrow opening angles of 5.6° along 32 different stripe directions ranging from [-110] to [1-10]. This is in contrast to the usual approach of using large opening angles that maximize the amount of lateral ELO material per length of coalescence front. We observe multipoint coalescence as forming dimples or voids along the coalescence front and find that their formation occurs most often in the orientations with the highest overall coalescence rate. Our results illustrate the balance between mixed-plane sidewall formation and lateral sidewall growth rate, allowing optimization of multipoint coalescence and the resultant dimples. We present SEM images showing that slight deviations from high rate/high void orientations and tuning of growth parameters, especially Phosphorus overpressure, allow for the elimination of these voids by changing the sidewall faceting at the moment of coalescence. Further information from ongoing Atomic Force Microscopy, Luminescence and Transmission Electron Microscopy characterization of the resulting coalescence fronts will be presented as well.

[1] Olsson F, et. al., J. Appl. Phys. 104, 093112 (2008)
[2] Yan Z, et.al., J. Crystal Growth 212, 1 (2000)

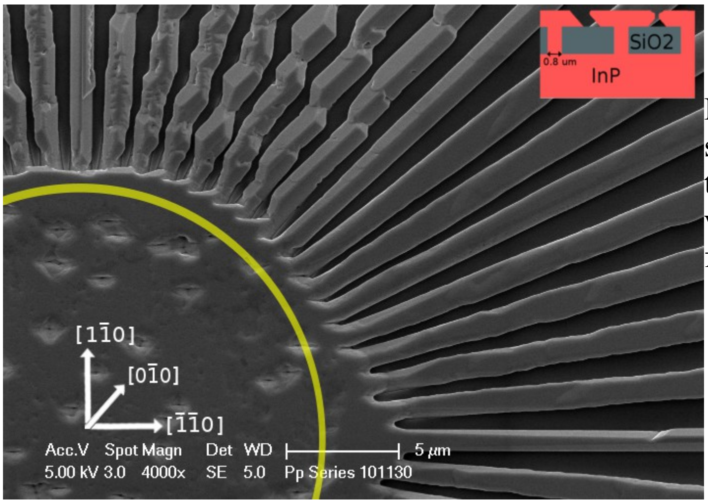

Figure 1: Morphological dependence on stripe direction. Notice the stripes above the [0-10] direction are highly faceted while those below have smoother growth fronts.

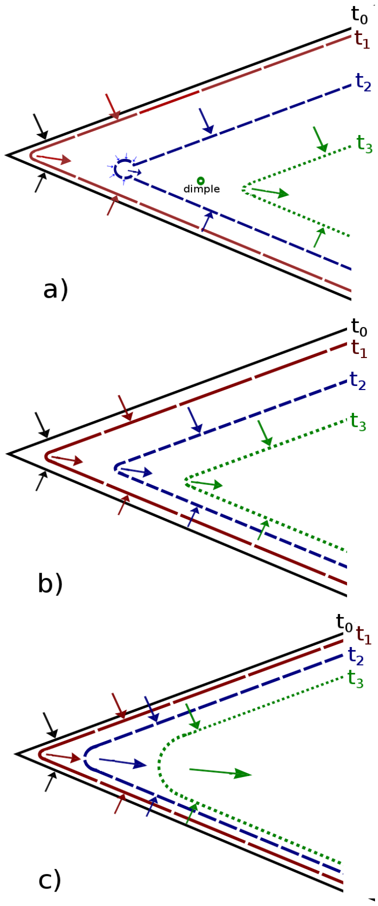

Figure 2: Illustration of the convergence of two directional growth fronts yields a third of dissimilar growth rate. This drawing illustrates the result when this third growth direction is a) slower than, b) equal to, and c) faster than the sum of the two merging growth front vectors. When this direction is too slow, dimples form. When this direction is fast, the neighboring sidewalls tend to be too slow.

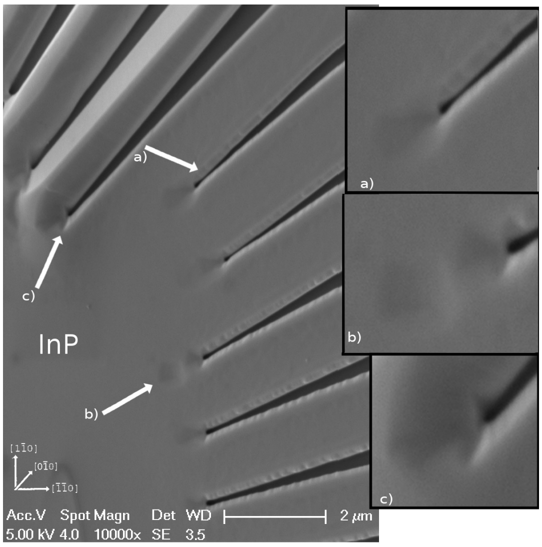

Figure 3: A variety of convergent growth directions and sidewall morphologies, illustrating a) near convergence of sidewalls, b) a resultant dimple, c) lowest rate of convergence for the most dissimilar sidewall morphologies.

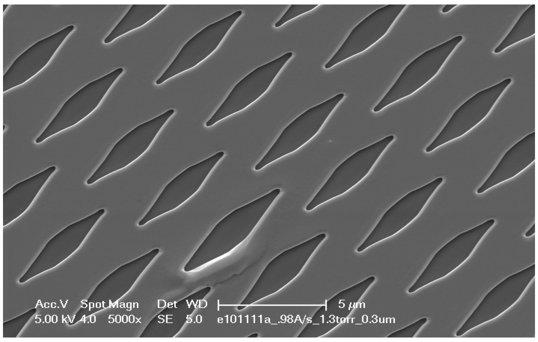

Figure 4: Islands over which opposing growth fronts move faster than their common intersection points, a prelude to dimple formation.