

Influence of the initial phase distribution on antiphase domains control and burying in MBE growth of III-Vs on “on-axis” Si

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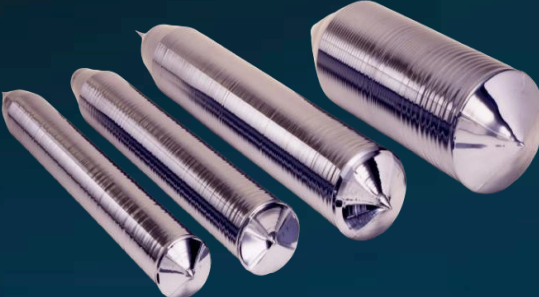
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Context

Monolithic integration for photonic integrated circuits (PICs)

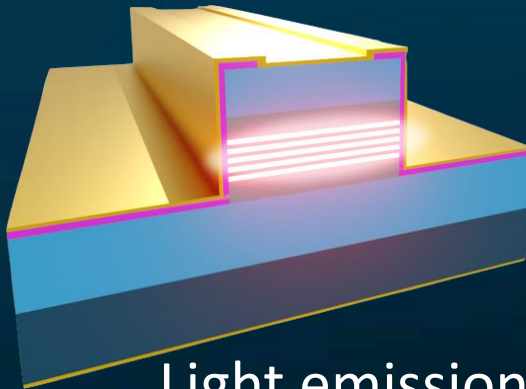
Silicon(001):



Large-scale and low-cost manufacturing



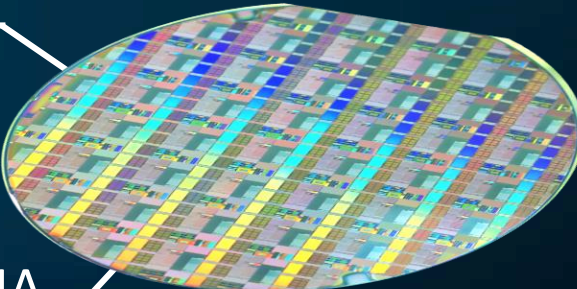
III-V:



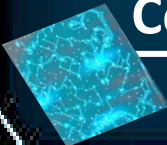
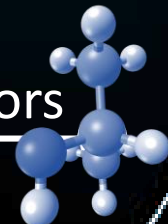
Light emission



Communication: optical datacom

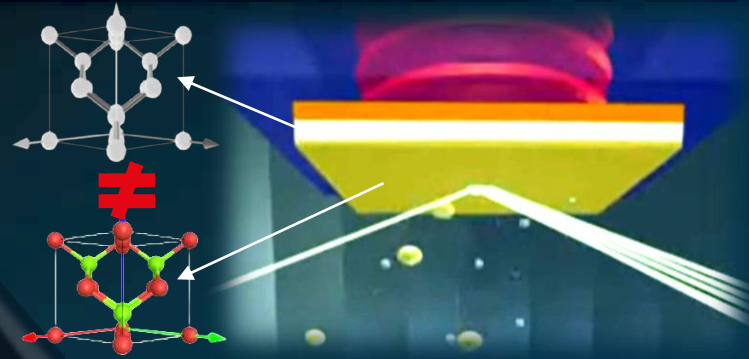


Sensing: gas sensing, biosensors



Computing: quantum computing, IA

Challenges



Twins

Substrate preparation



APBs

Polar on non-polar

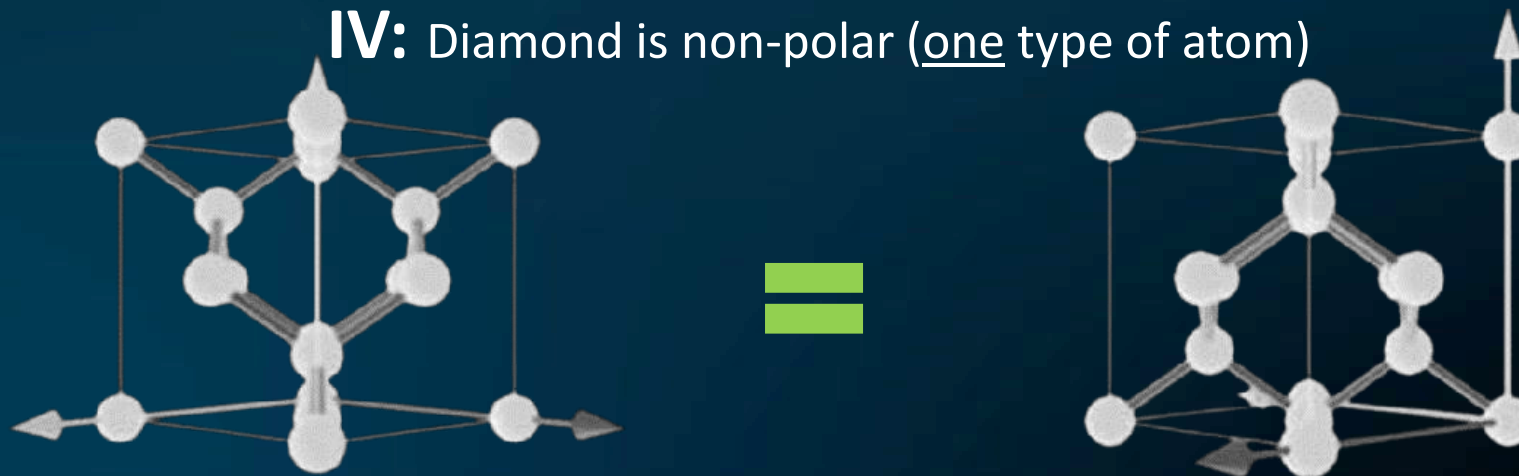
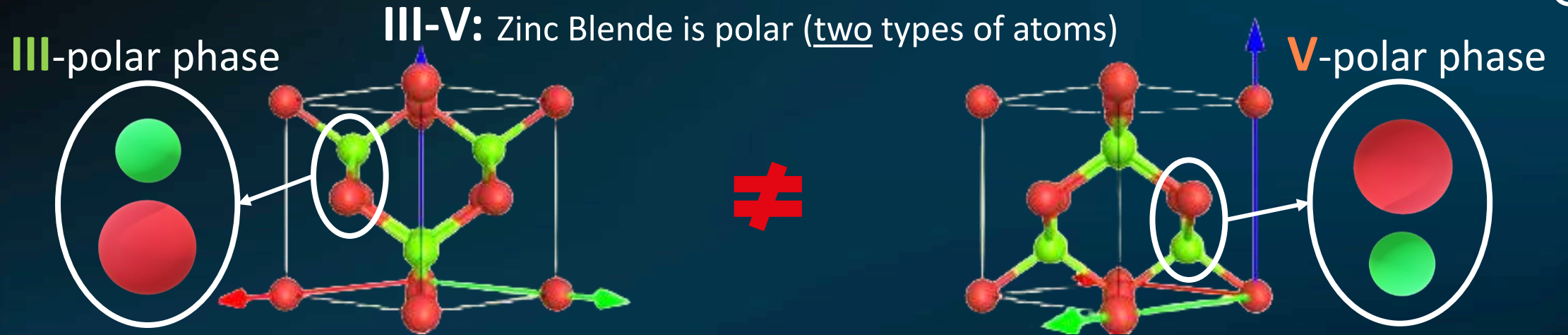


Dislocations

Lattice mismatch



Challenges



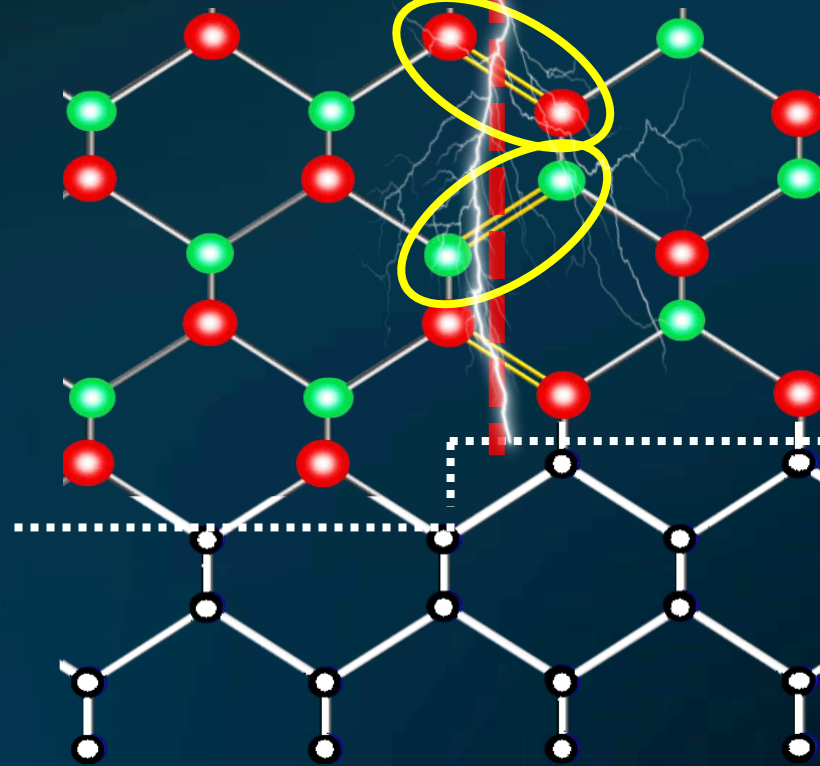
Higher degree of symmetry

Challenges

APB = short-cut

III-polar phase

V-polar phase



Monoatomic Si step

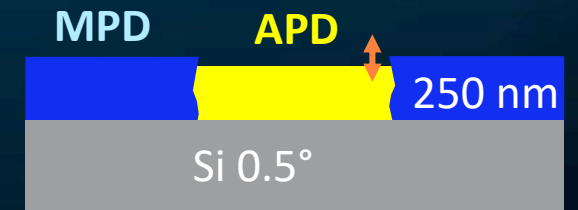
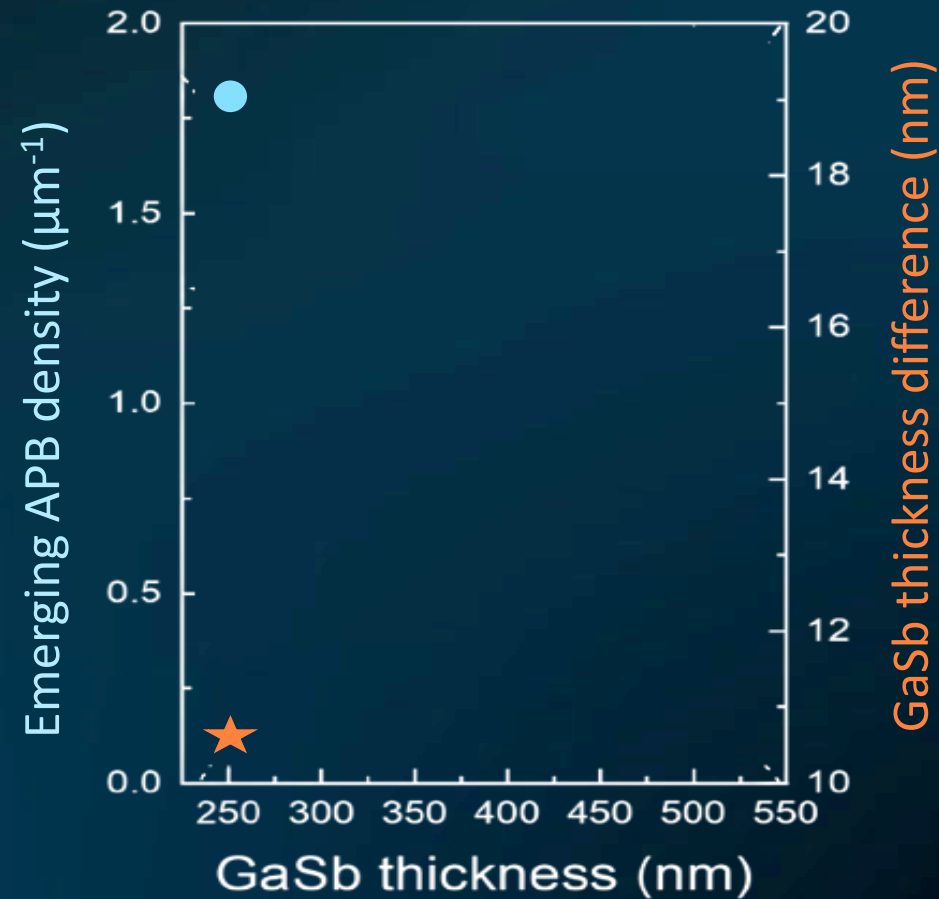
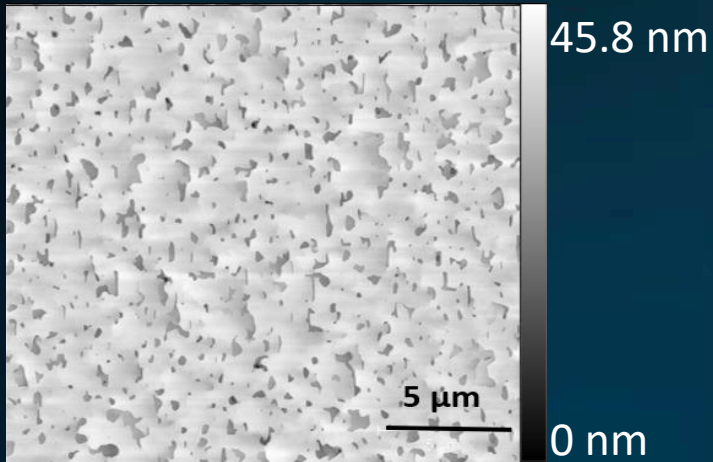


Few demonstrations of APB annihilation

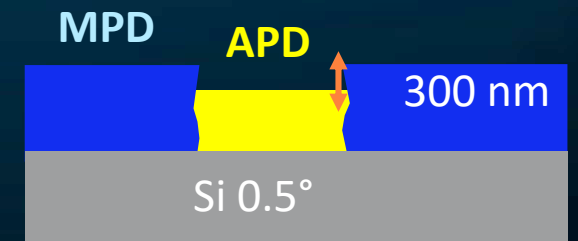
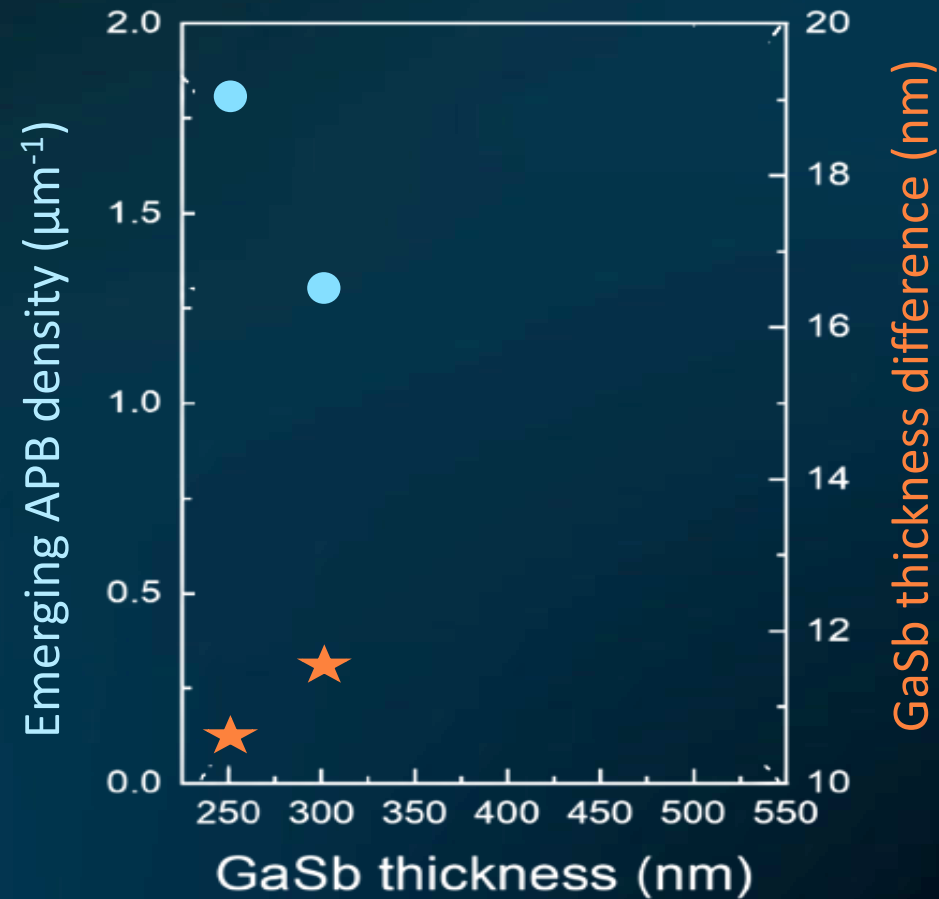
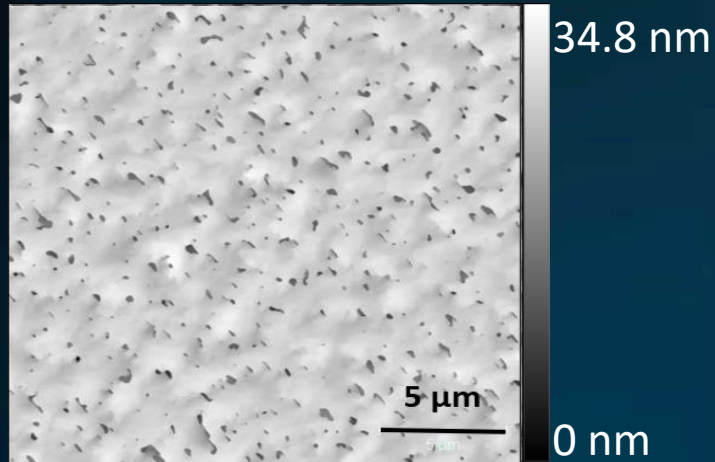


No clear explanation of the mechanism

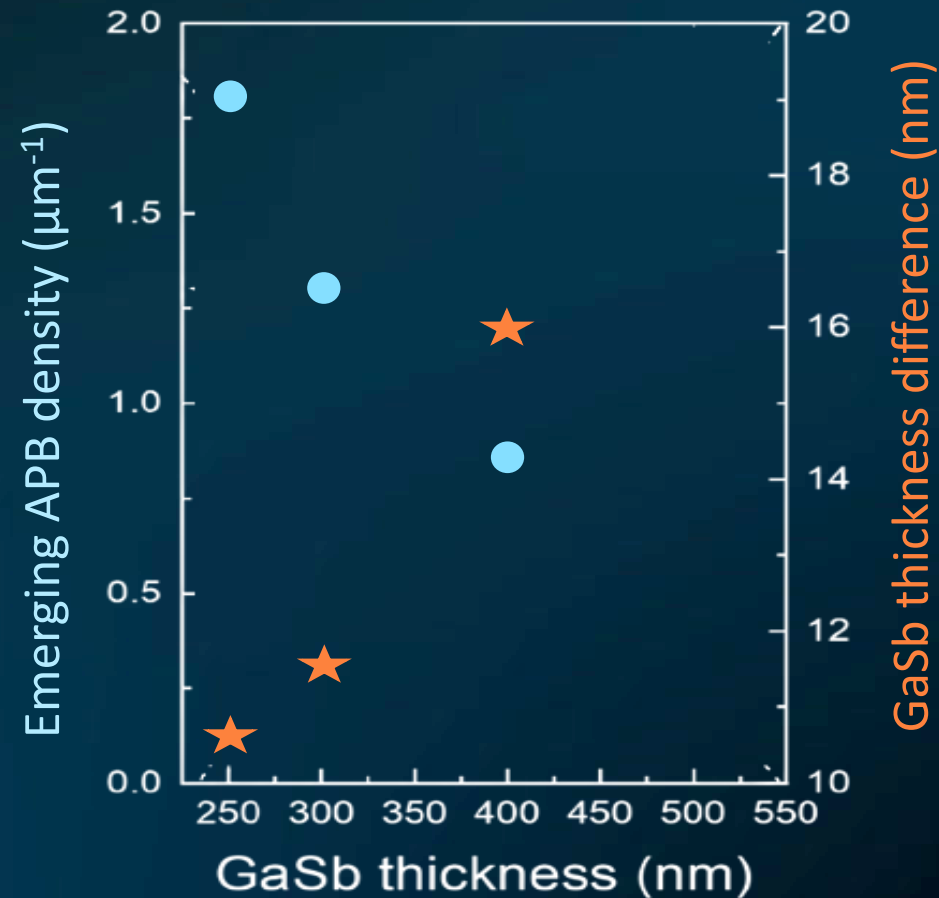
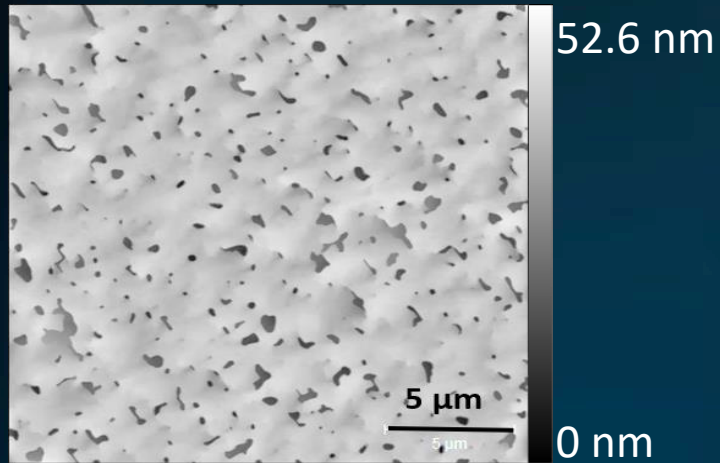
GaSb on Si APD burying



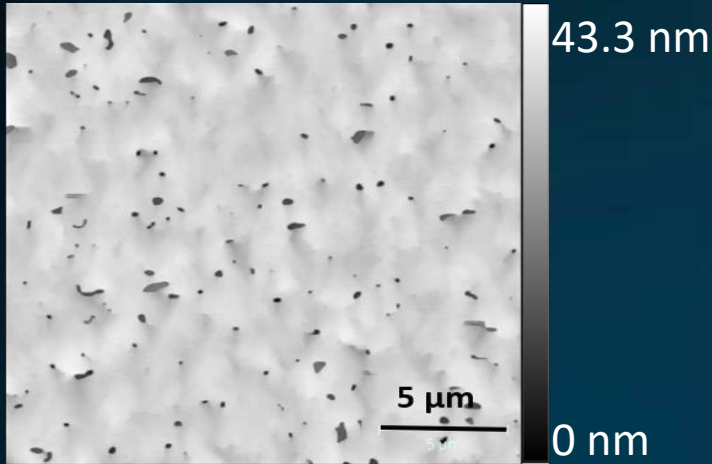
GaSb on Si APD burying



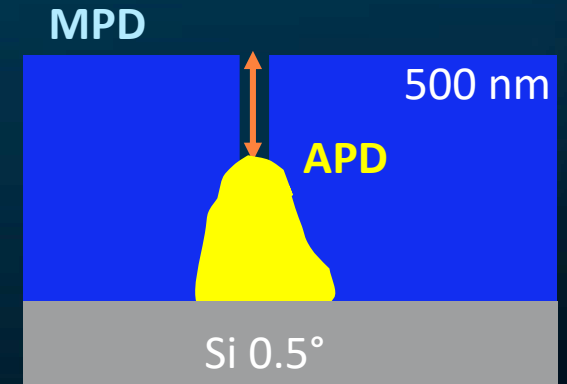
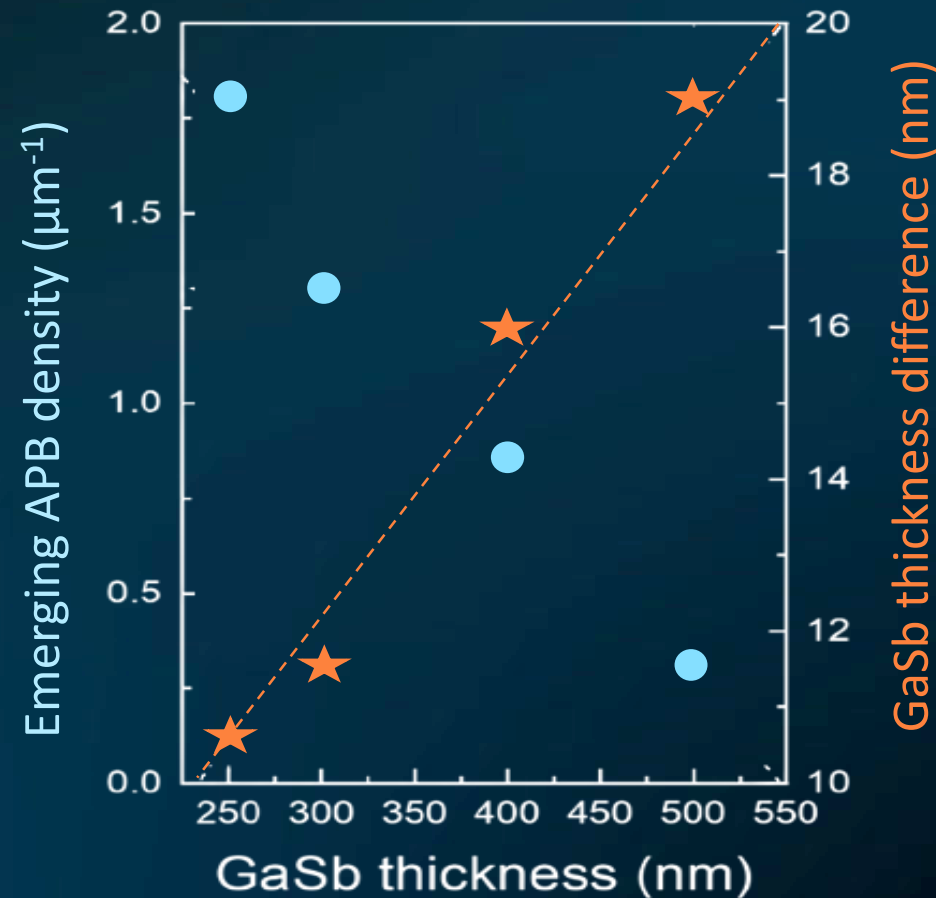
GaSb on Si APD burying



GaSb on Si APD burying



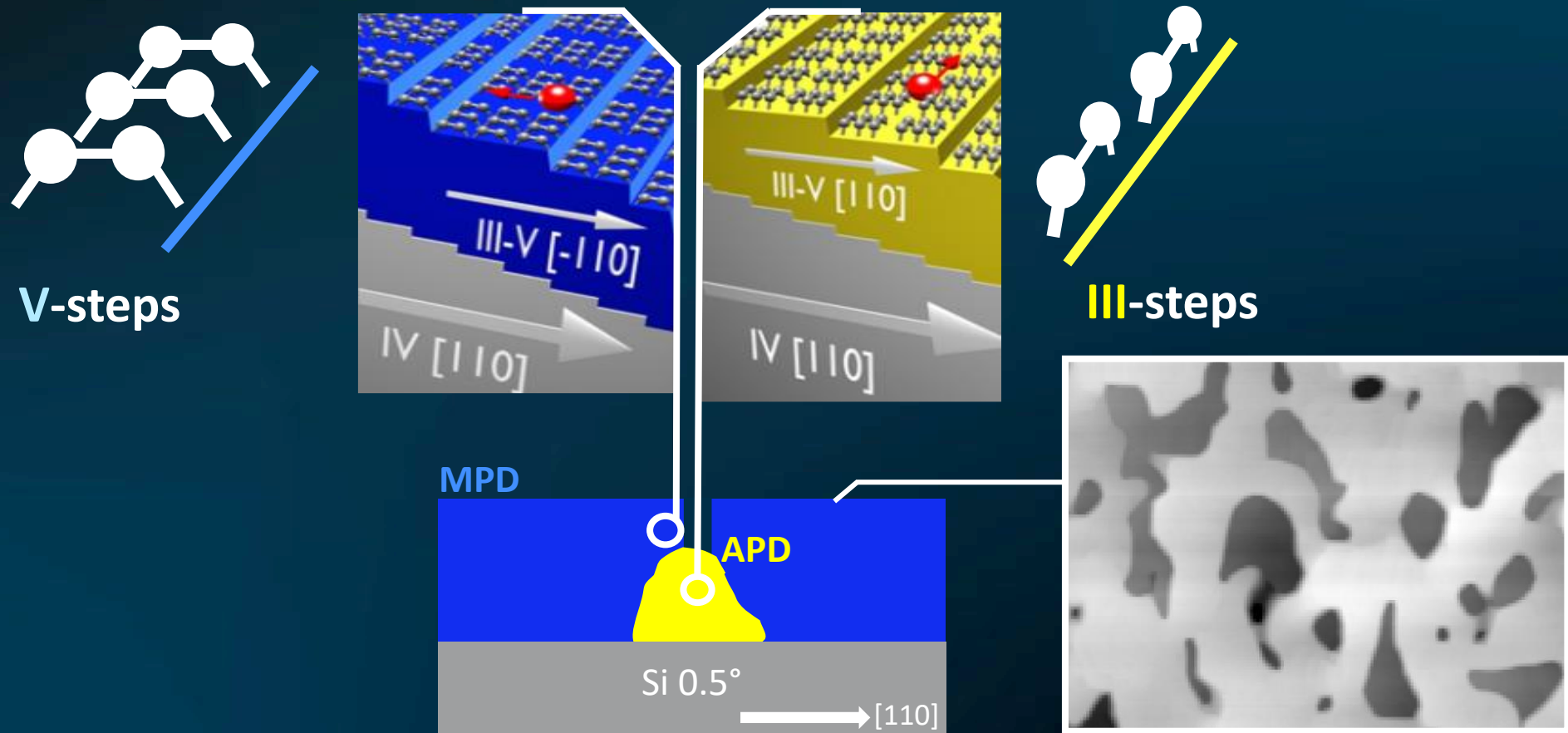
APD density ↓ :
progressive burying



Depth difference ↑ :
3% growth rate difference

One domain grows slower and is buried

➤ Anisotropy: different steps' composition

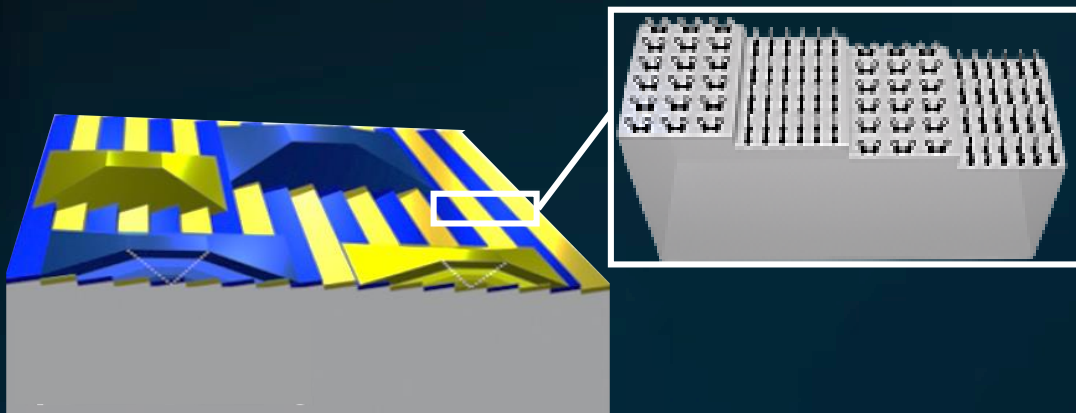


➤ Miscut transfer in [110] direction: breaks the symmetry

APDs morphologies

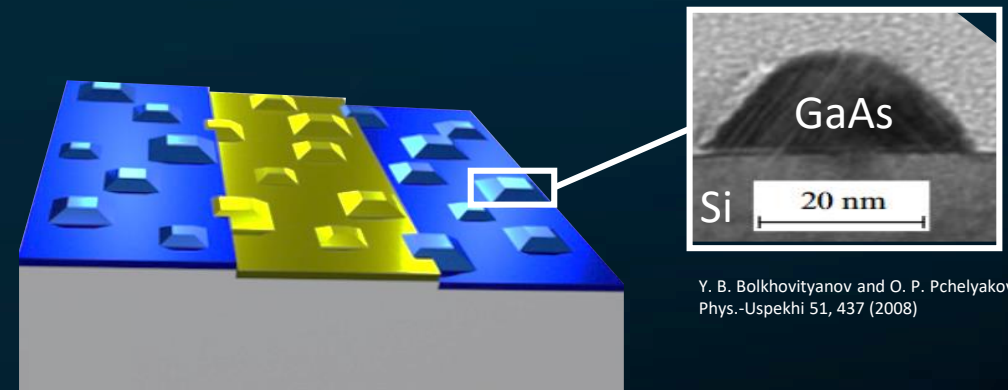
Initial phase distribution:

Nucleation-driven



Initial island size $>$ terraces width

Terrace-driven

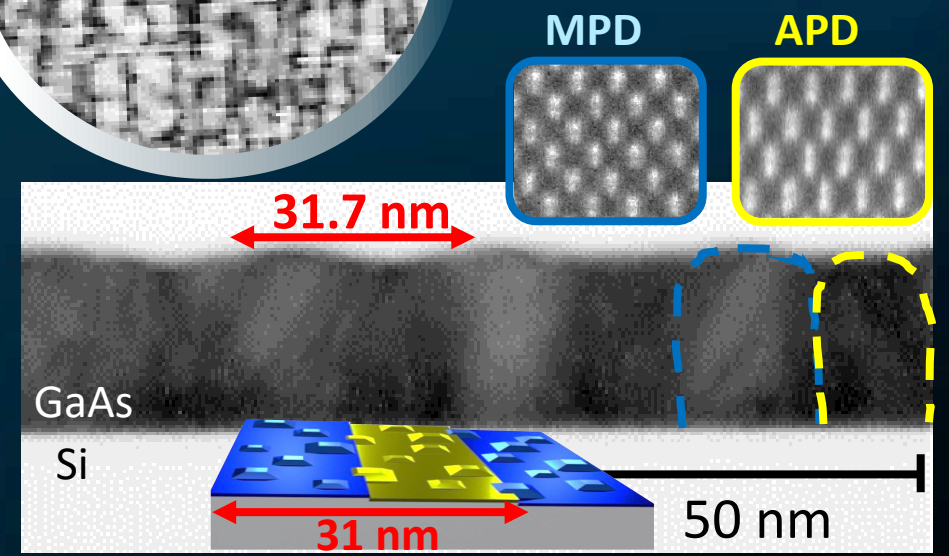
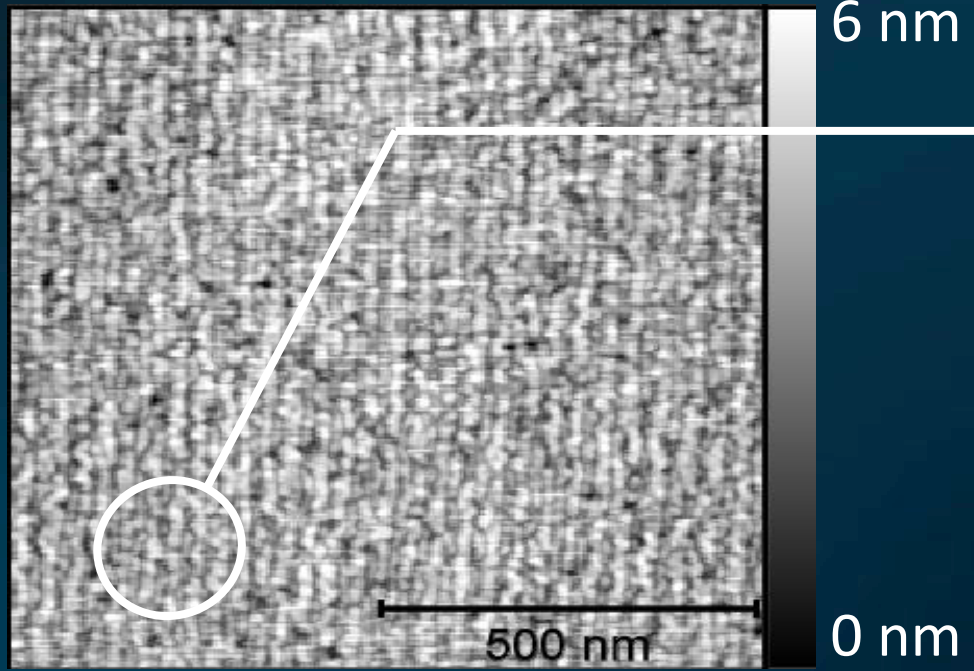
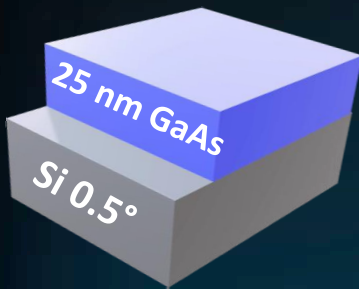


Y. B. Bolkhovityanov and O. P. Pchelyakov,
Phys.-Uspekhi 51, 437 (2008)

Initial island size $<$ terraces width

Terrace-driven regime burying

LOW T°C growth

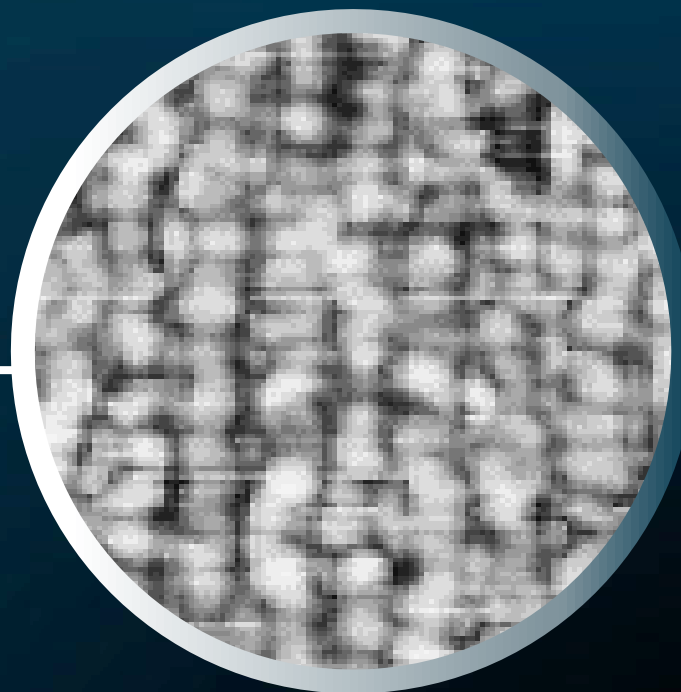
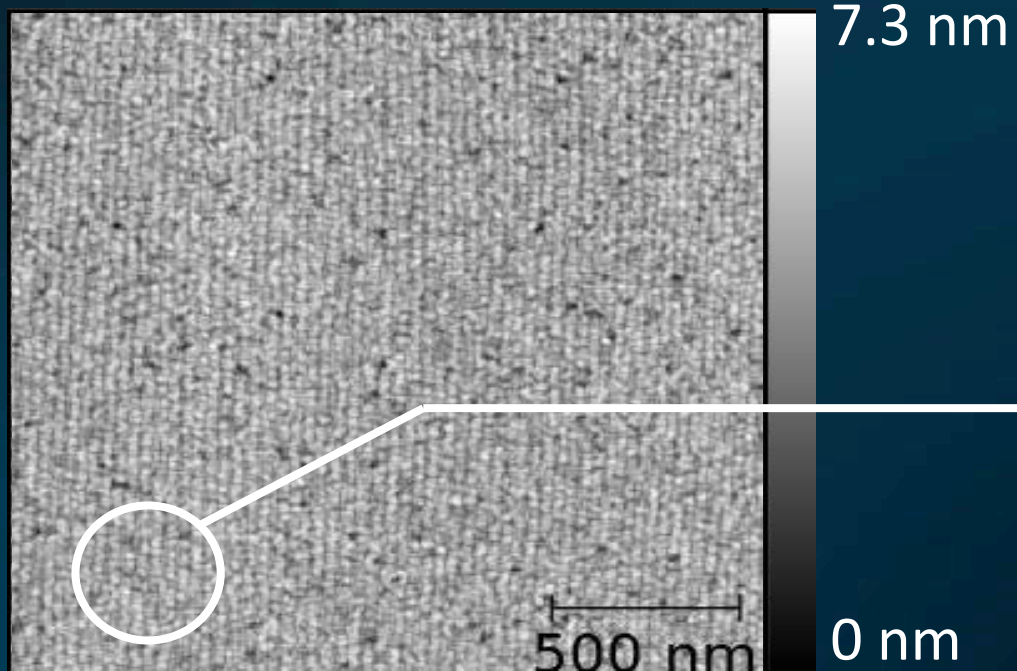
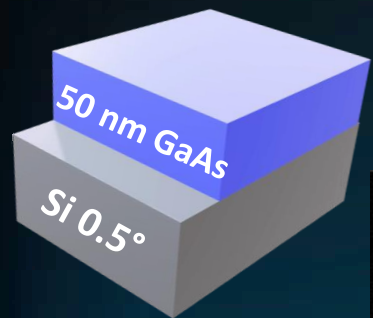


Stripes alternation

APD/MPD alternation

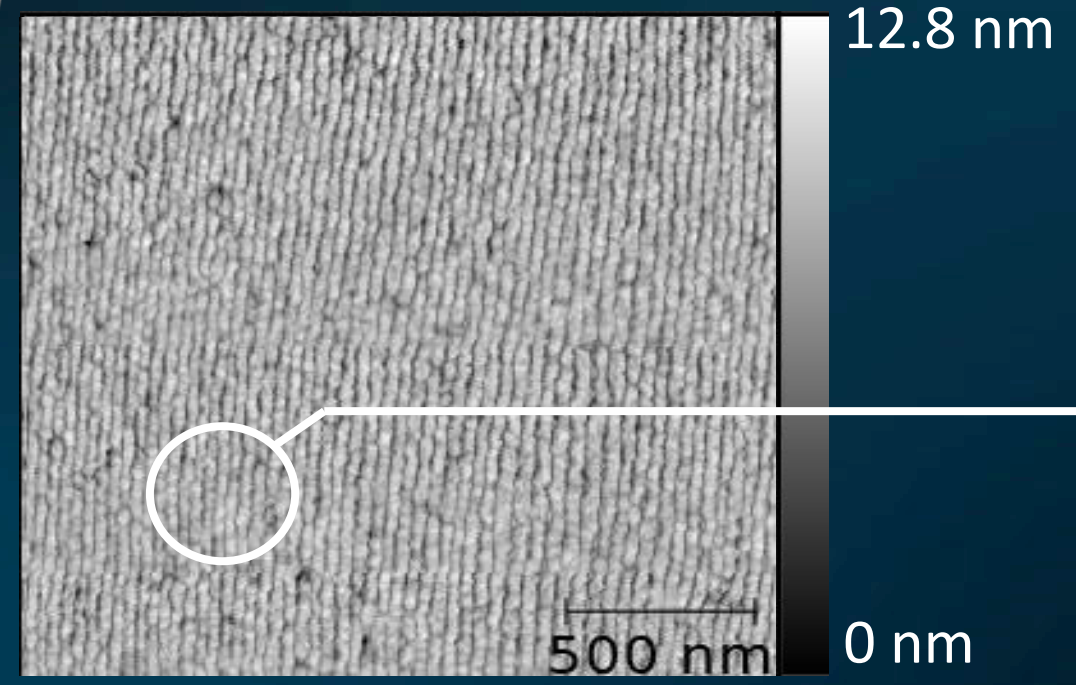
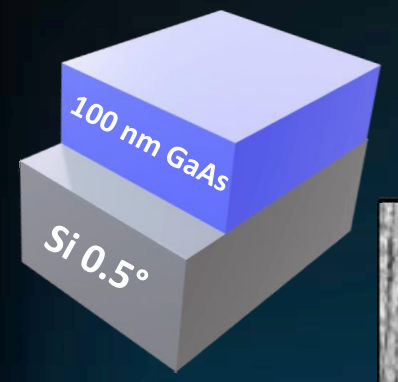
✓ Terrace-driven initial phase distribution

LOW T°C growth

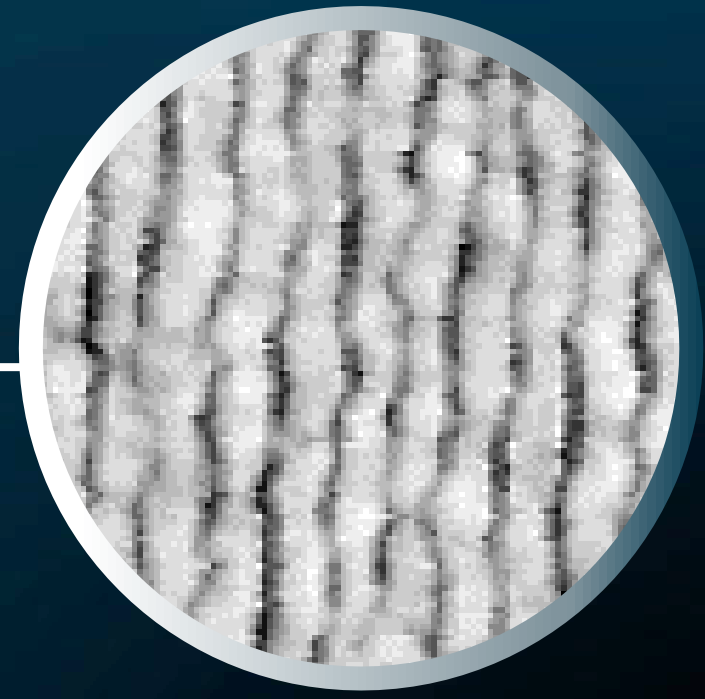


APD stripes shrinks

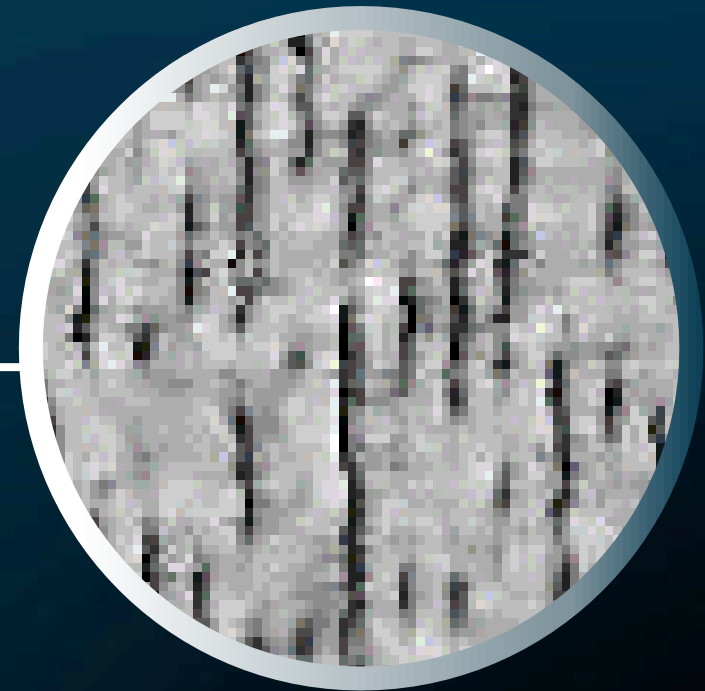
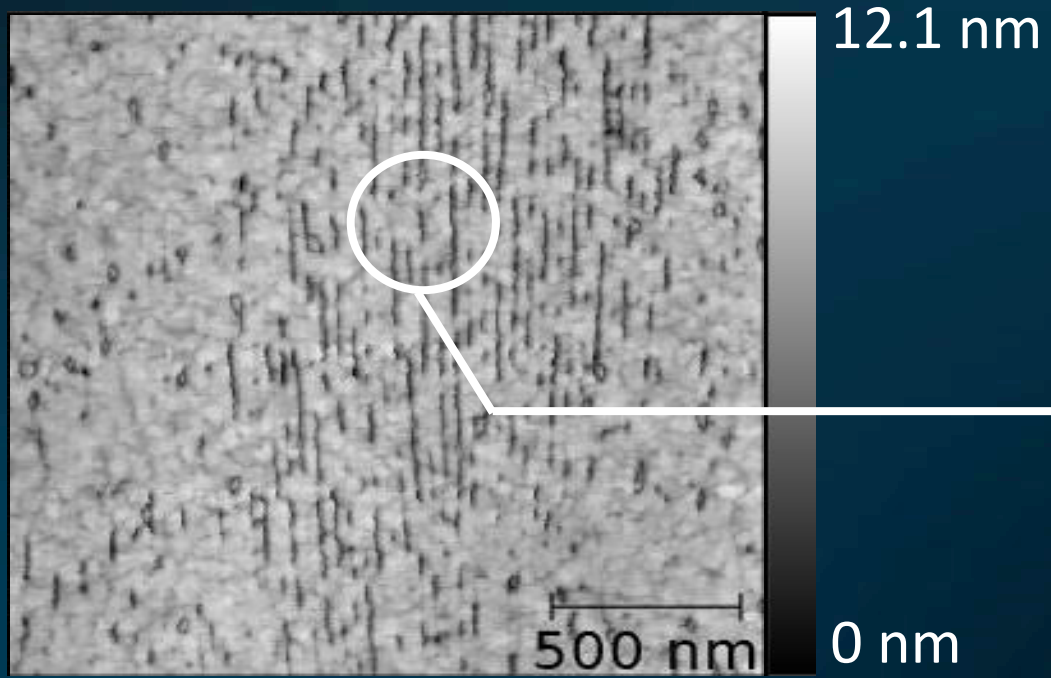
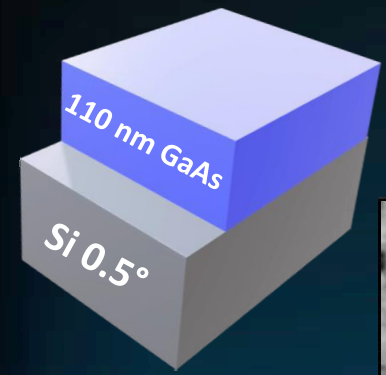
LOW T°C growth



Lines

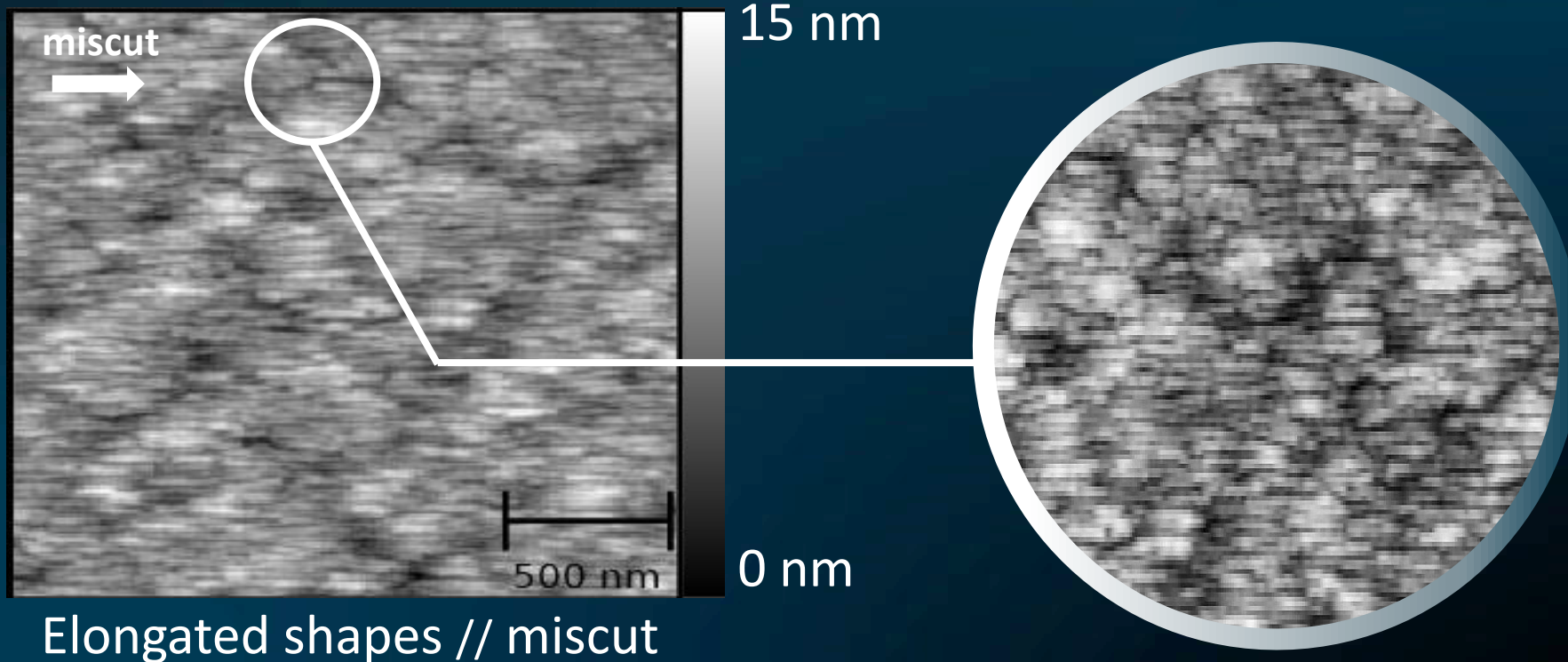
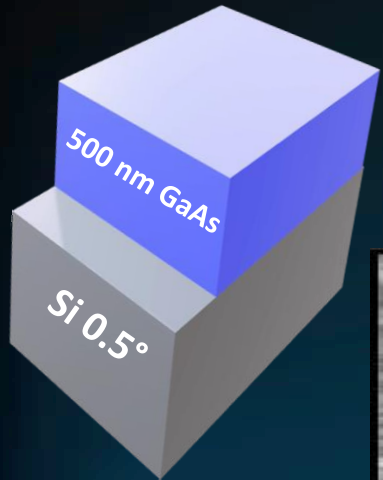


LOW T°C growth



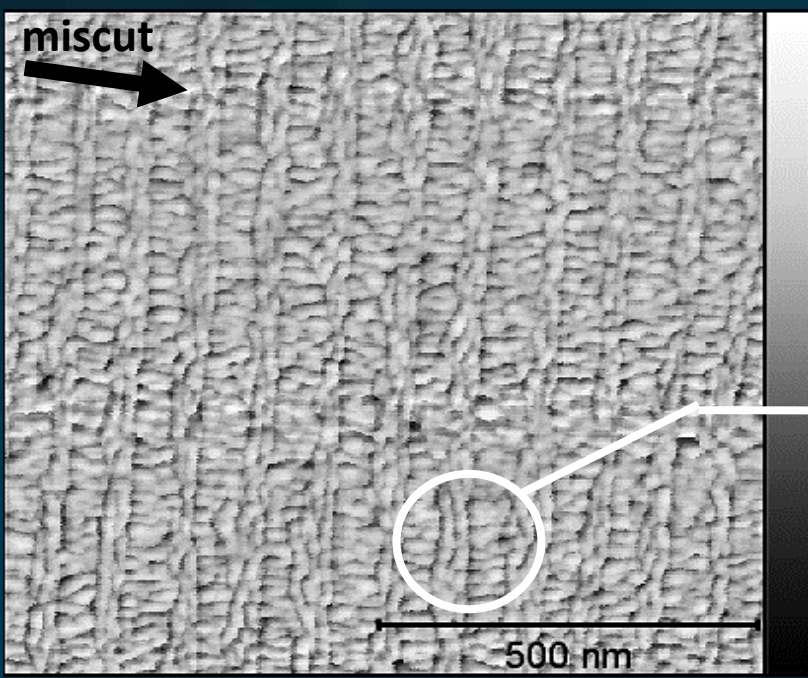
Lines disappear

100 nm LOW T°C + 400 nm MT°C

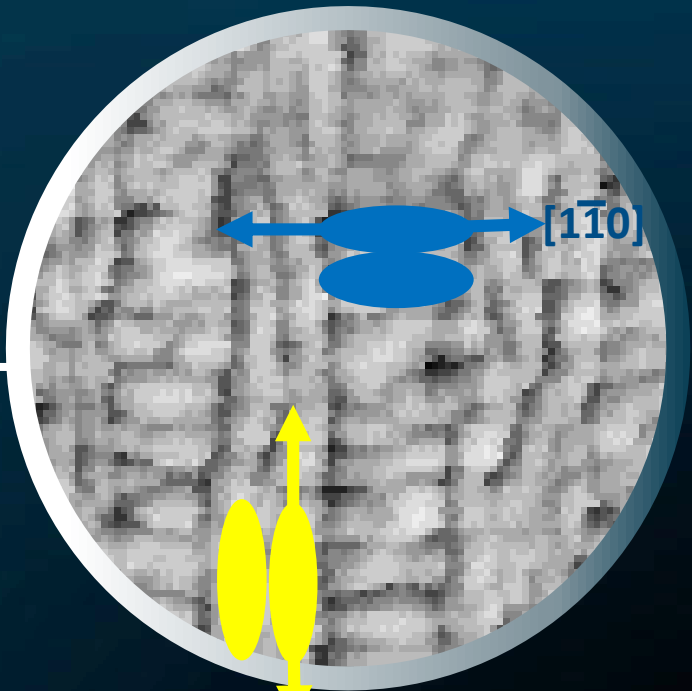


No step-flow: why one phase grows faster?

➤ Anisotropy: diffusion length of group-III atoms



9 nm Islands grow faster in $[1\bar{1}0]$ direction

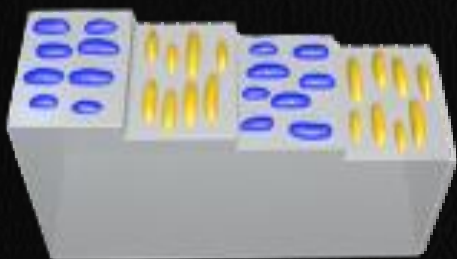


0 nm

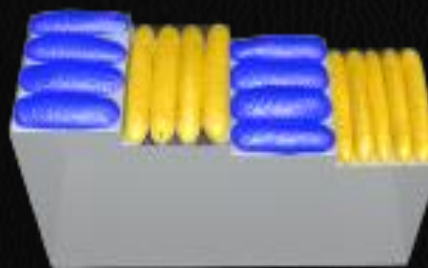
➤ Miscut: perpendicular elongation directions

Terrace-driven regime burying

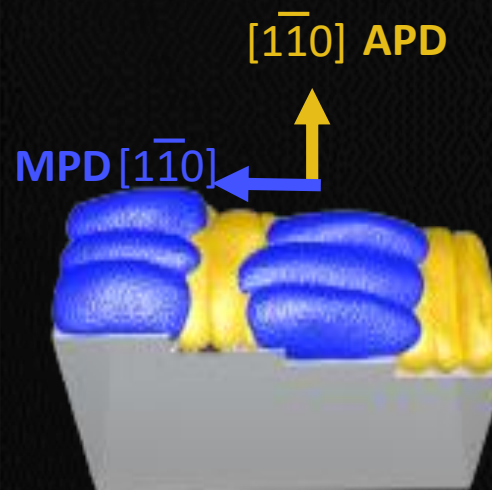
3D islands smaller than
Si monoatomic steps



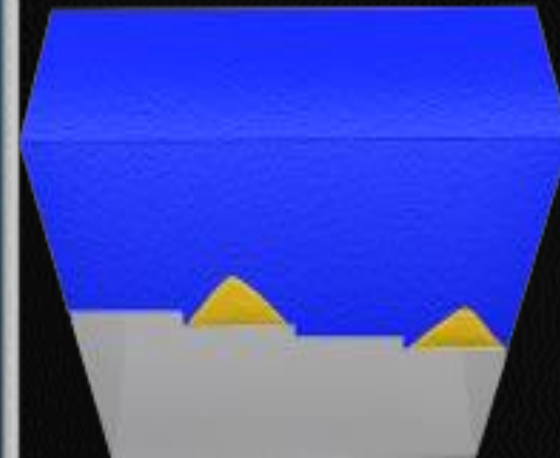
Coalescence contained
in terraces:
Alternation APD/MPD



Faster growth in $[1\bar{1}0]$:
MPD overflows APD

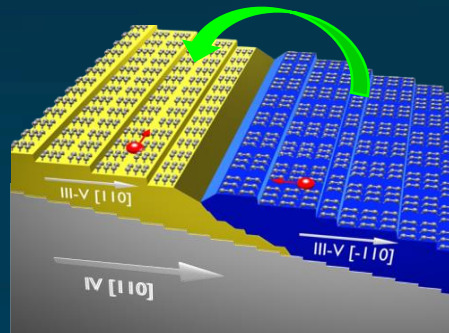
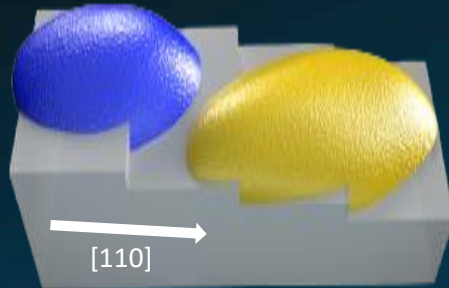


APD is buried



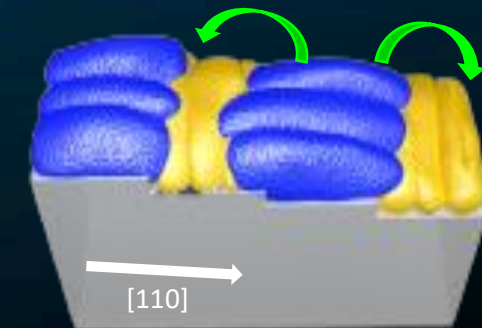
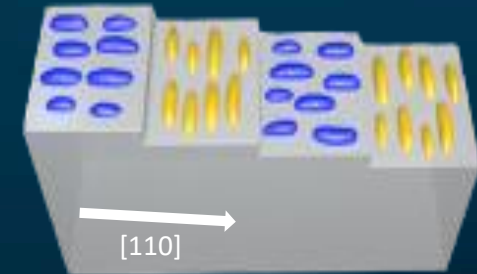
Conclusion

Nucleation-driven



No APBs: 550 nm GaSb/Si 0.5°

Terrace-driven



No APBs: 150 nm GaAs/Si 0.5°

➤ **Miscut:**
transfer in [110] direction =
breaks the symmetry

➤ **Anisotropy:**
faster incorporation in V-steps /
faster island elongation in $[\bar{1}10]$



Thank you
for your attention

