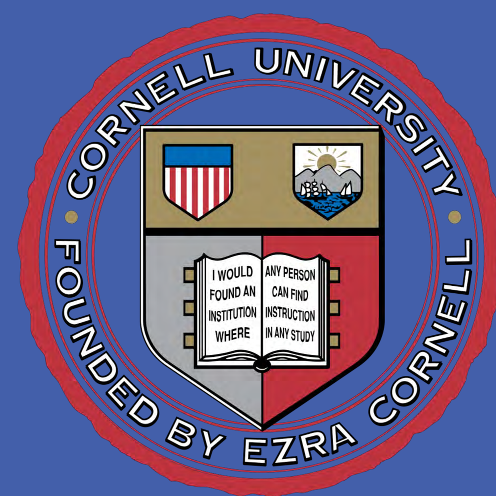
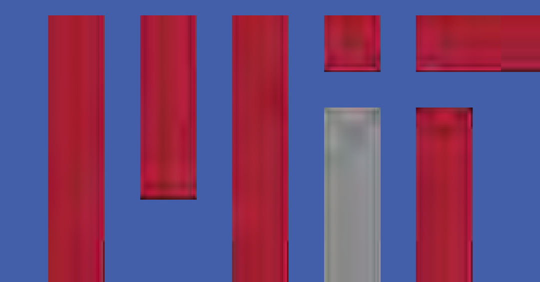


Etch Pit Density Analysis of Ternary III-V Semiconductor Heterostructures



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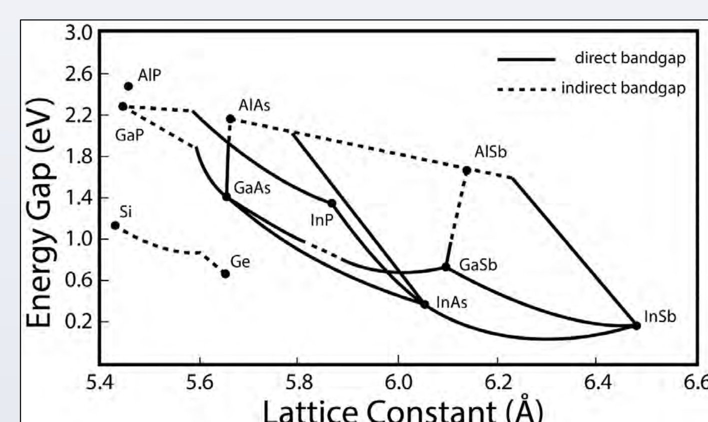
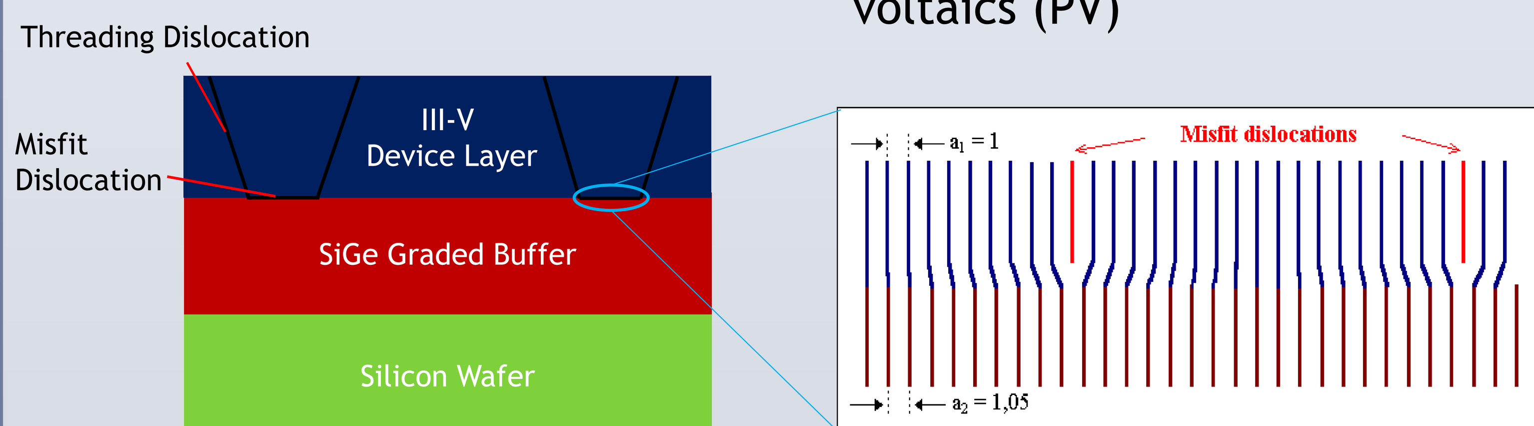
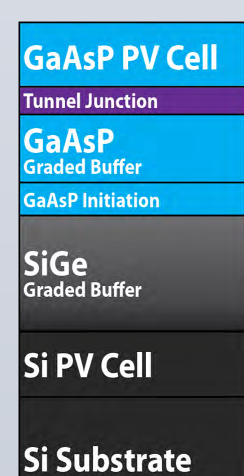
Introduction



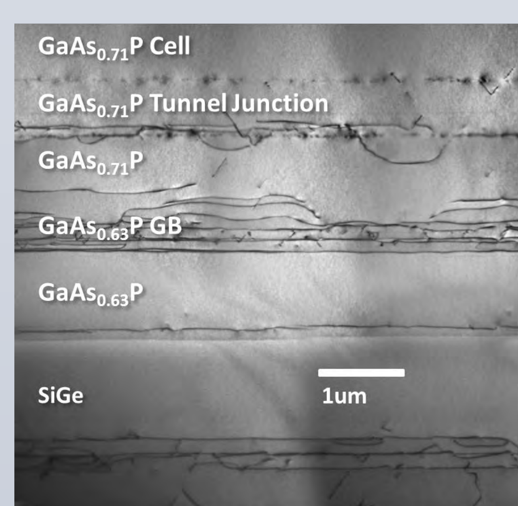
- Ternary III-V materials have numerous applications in electronics due to their variable energy structures
- Lattice constant differences between layers can cause strain that results in misfit dislocations at layer interfaces and threading dislocations in crystal bulk
- These dislocations can detrimentally affect device performance, especially in photo-voltaics (PV)
- Current methods to measure dislocation densities are time-consuming and limited to only high dislocation densities



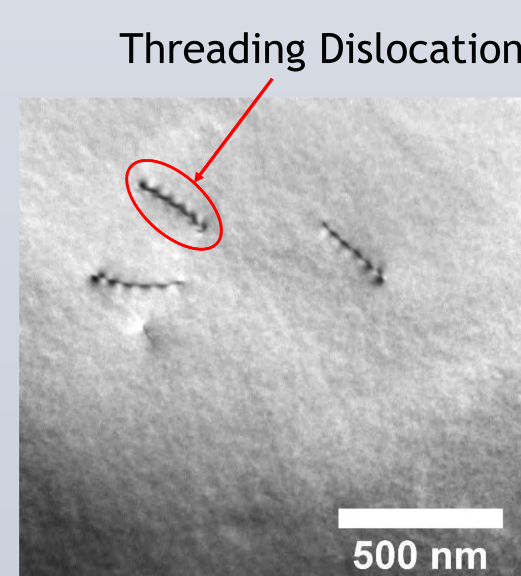
Threading Dislocation



Dual Junction Cell Schematic[1]

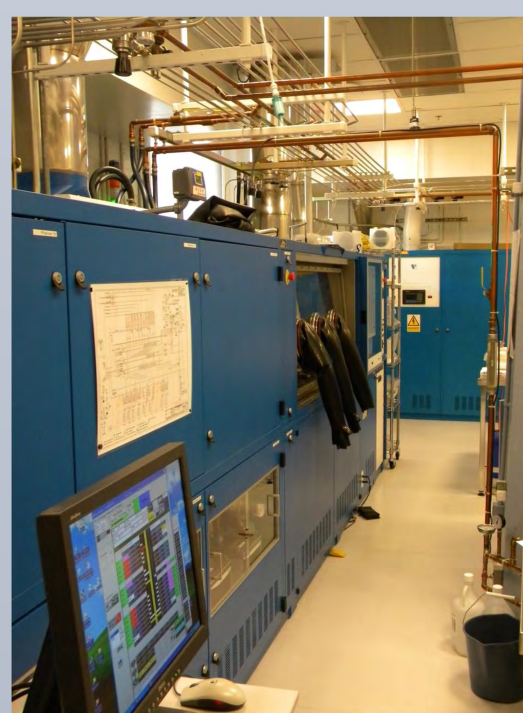


Cross Section TEM (g=(220))[1]



Plan view TEM (g=(220))[2]

Materials



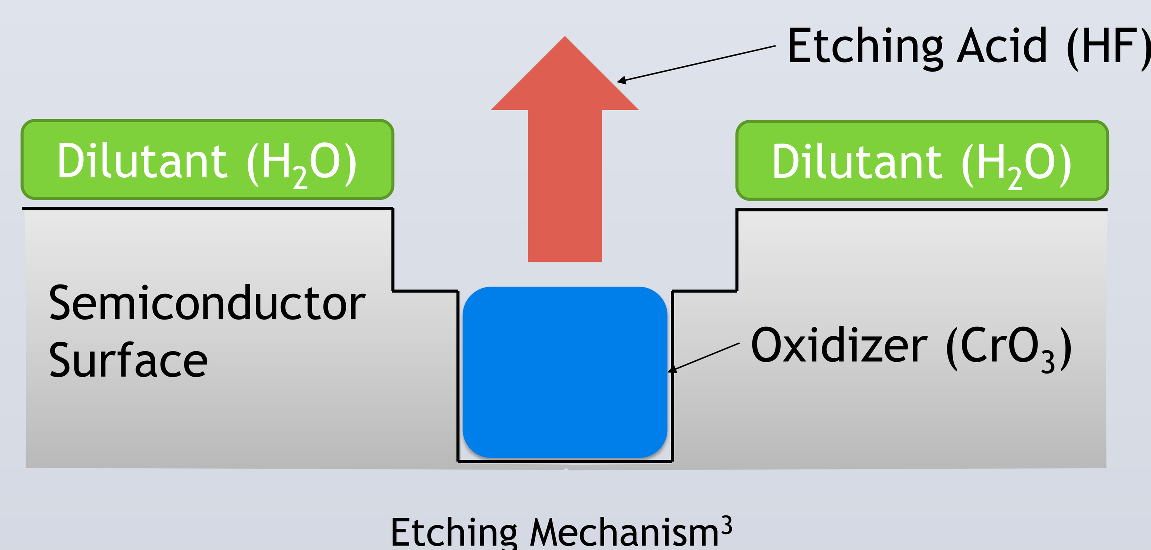
MOCVD Reactor

- Si_xGe_{1-x} graded buffers grown on silicon wafers in Ultra-High Vacuum Chemical Vapor Deposition (UHVCVD) Reactor
- All III-V devices layers were grown in Aixtron Metal-Organic Chemical Vapor Deposition (MOCVD) reactor

Close-Coupled Showerhead and reactor chamber of MOCVD Reactor

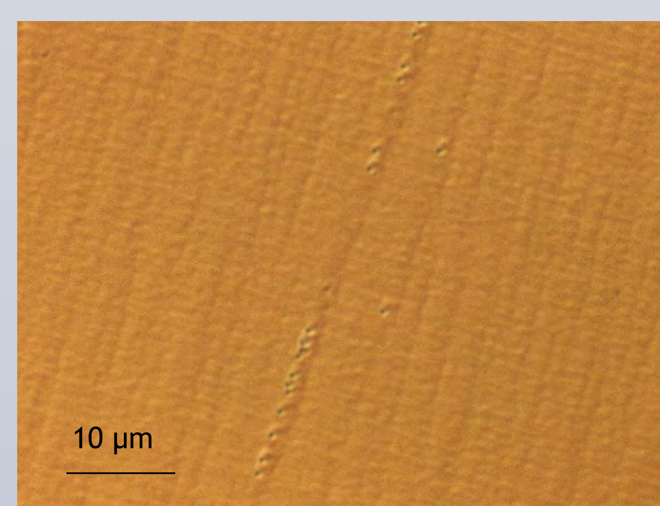
Etching Methods

- Etch pit density (EPD) measurements allow for very quick measurements of dislocation densities over large areas of a semiconductor's surface
- Dislocation Selective Etchants (DSEs) remove material much faster at a dislocation, forming etch pits at these sites
- Concentrated HCl was used to first remove a 20nm InGaP window on the top of GaAsP samples
- Both Molten KOH and a $CrO_3/HF/H_2O$ etches were examined as potential DSEs for GaAsP
- Samples were then viewed on a Nomarski microscope and etch pits were counted for density measurements

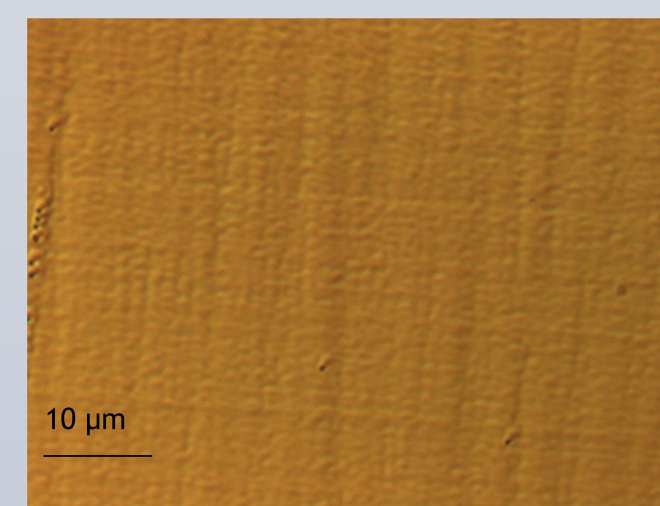


Etching Mechanism[3]

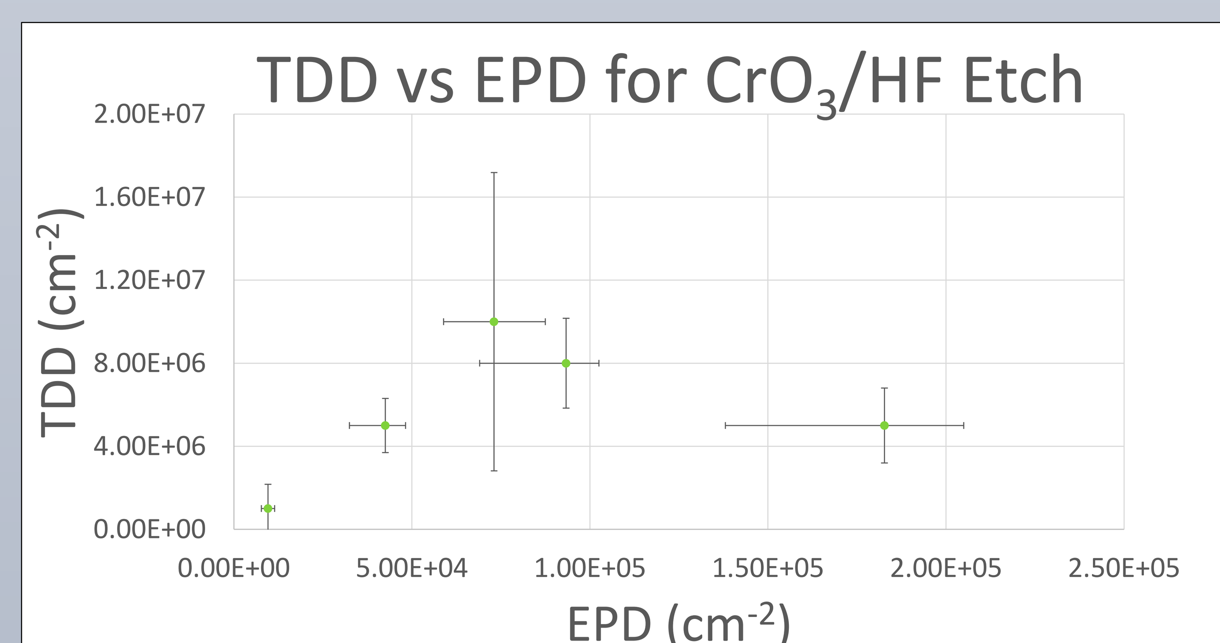
Results



Molten KOH 1000x



$CrO_3/HF/H_2O$ 1000x



Conclusion

- Of the etches investigated, only the $CrO_3/HF/H_2O$ and molten KOH etch produced etch pits
- Problems with cleanliness and contaminant deposition on sample surface made molten KOH etch data irreproducible
- $CrO_3/HF/H_2O$ etch produced repeatable etch pit densities
- EPD measurements were two orders of magnitude less than threading dislocation densities measured using plan view TEM

Future Work

- Perform SEM microscopy on etch pits created in KOH and $CrO_3/HF/H_2O$ etch to examine their crystallographic specificity and shape
- Adjust variables, such as temperature, and modify the procedure of the KOH etch in order to produce more reproducible results
- Investigate other etching chemistries for GaAsP as well as other ternary III-V compounds such as InGaAs and InGaSb

References

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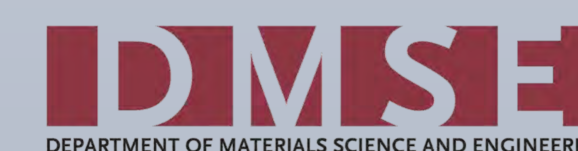
3. Lai, Jessica. *"Etch-Pit Density Survey of Germanium Silicon Graded Allots on Silicon"* June 1999.

Acknowledgements



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