

MONOLAYER-BY-MONOLAYER COMPOSITIONAL ANALYSIS OF InAs / InAsSb SUPERLATTICES WITH CROSS-SECTIONAL STM

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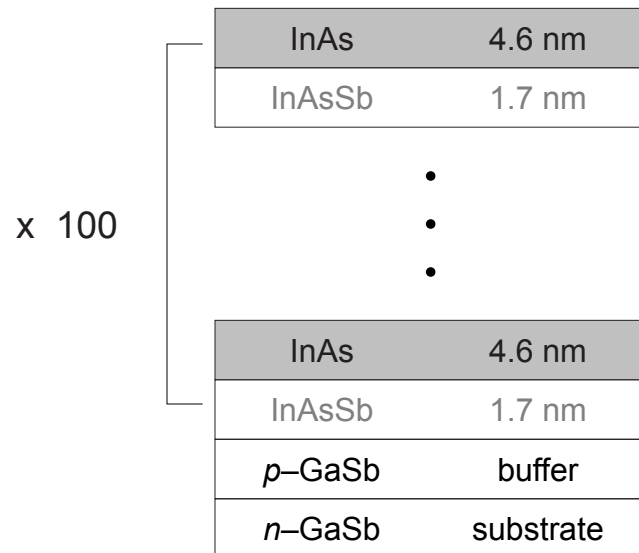
** mrwood@physics.tamu.edu*

Work supported by Sandia National Laboratories

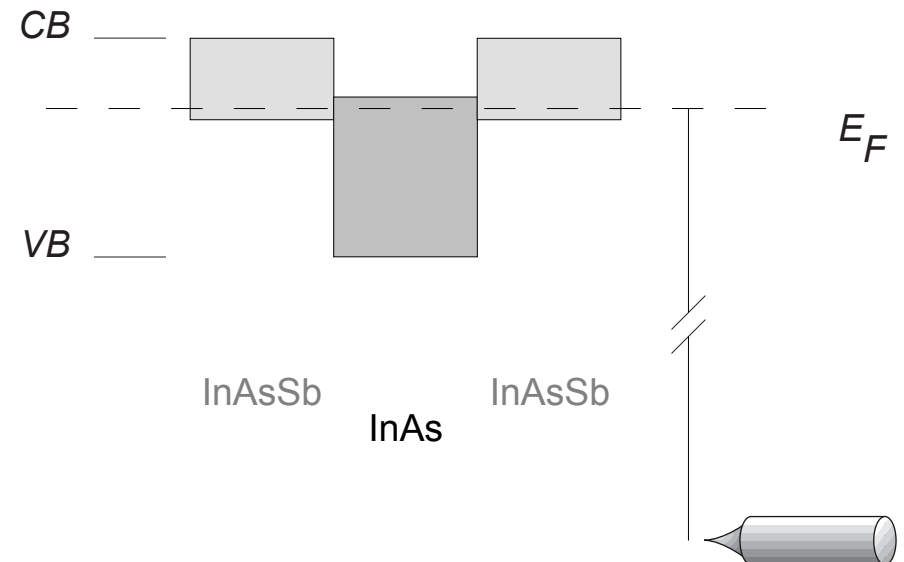
InAs / InAsSb SUPERLATTICE

Bandgap Engineered Structure

layer sequence

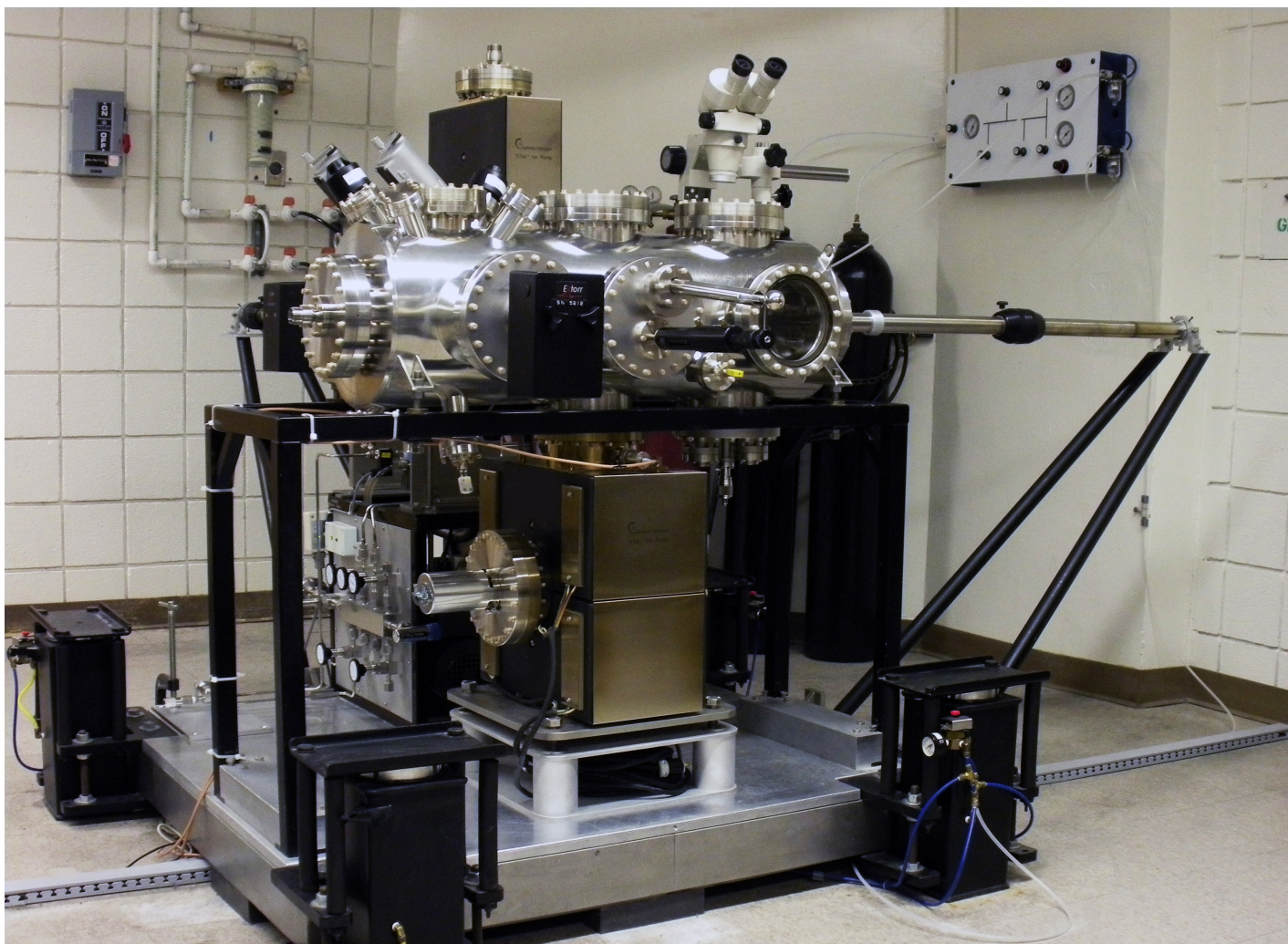


bulk band alignment



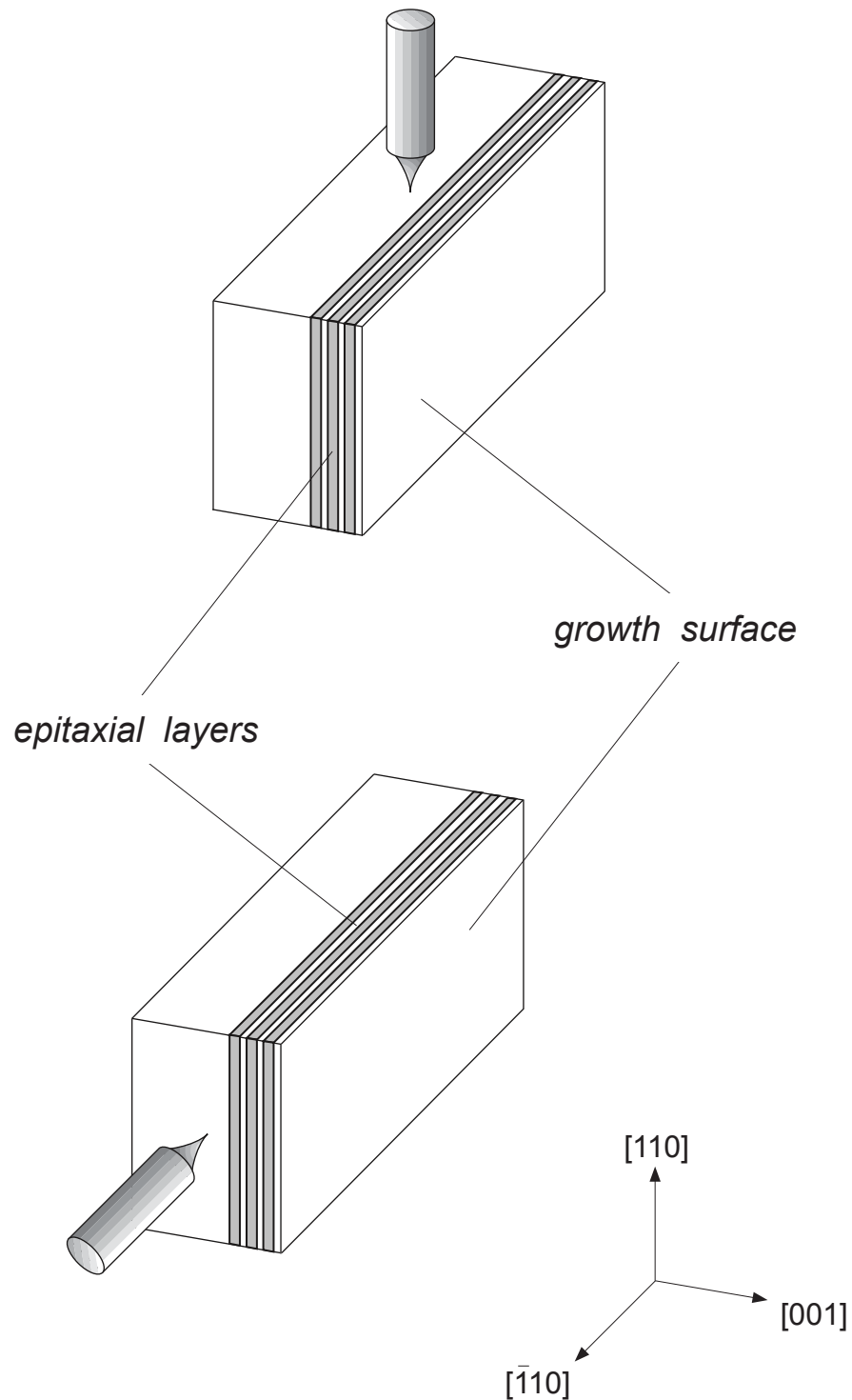
DEVICE-SCALE CHARACTERIZATION

Cross-Sectional STM



CROSS-SECTIONAL STM

(110) vs $(\bar{1}\bar{1}0)$ Cleavage



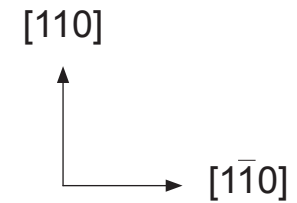
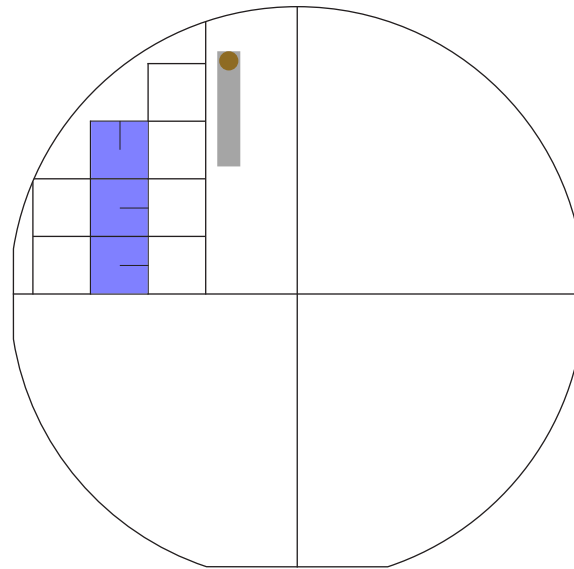
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INAs / INAsSb SUPERLATTICE

Wafer Diagram



x-ray illumination



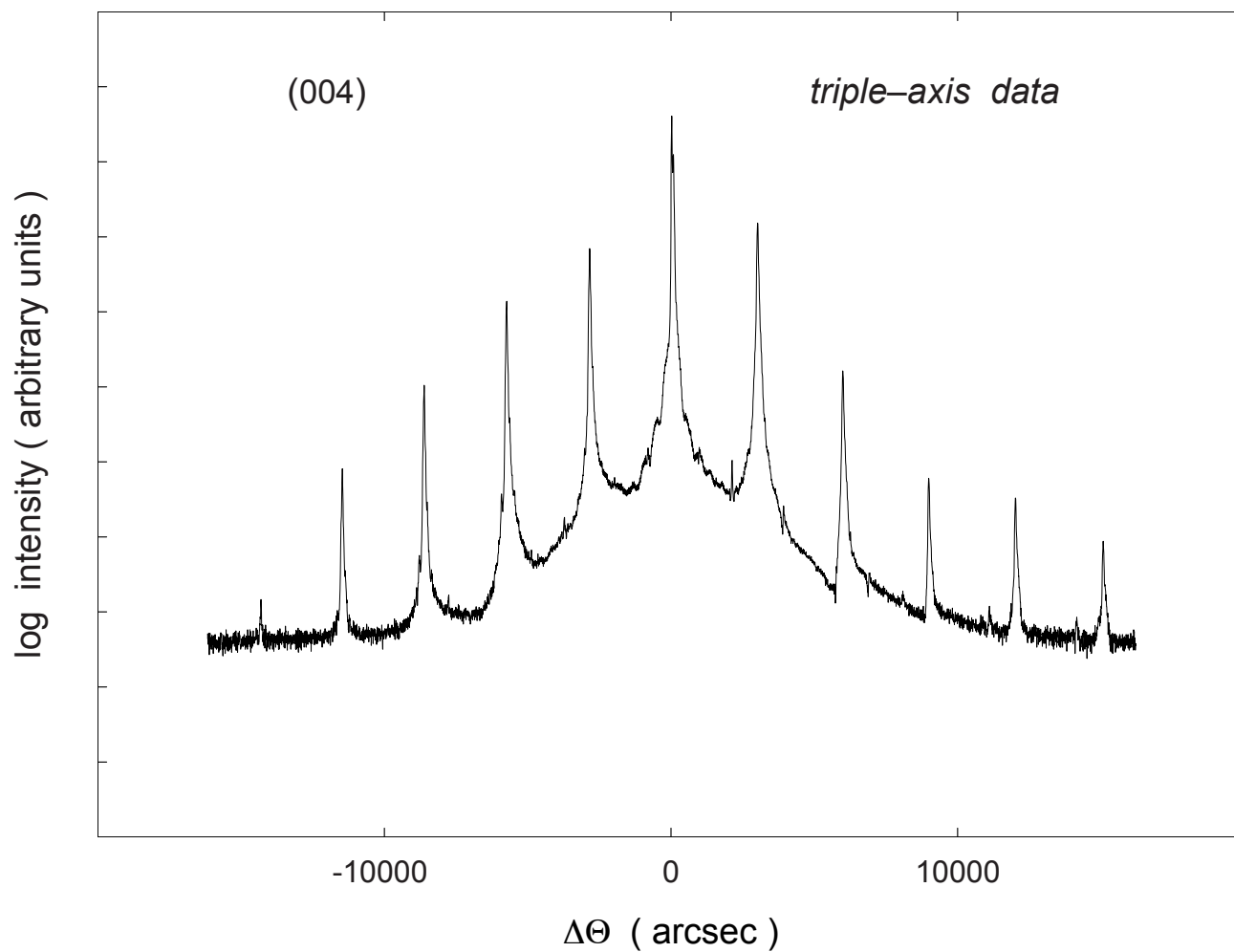
STM die



SIMS

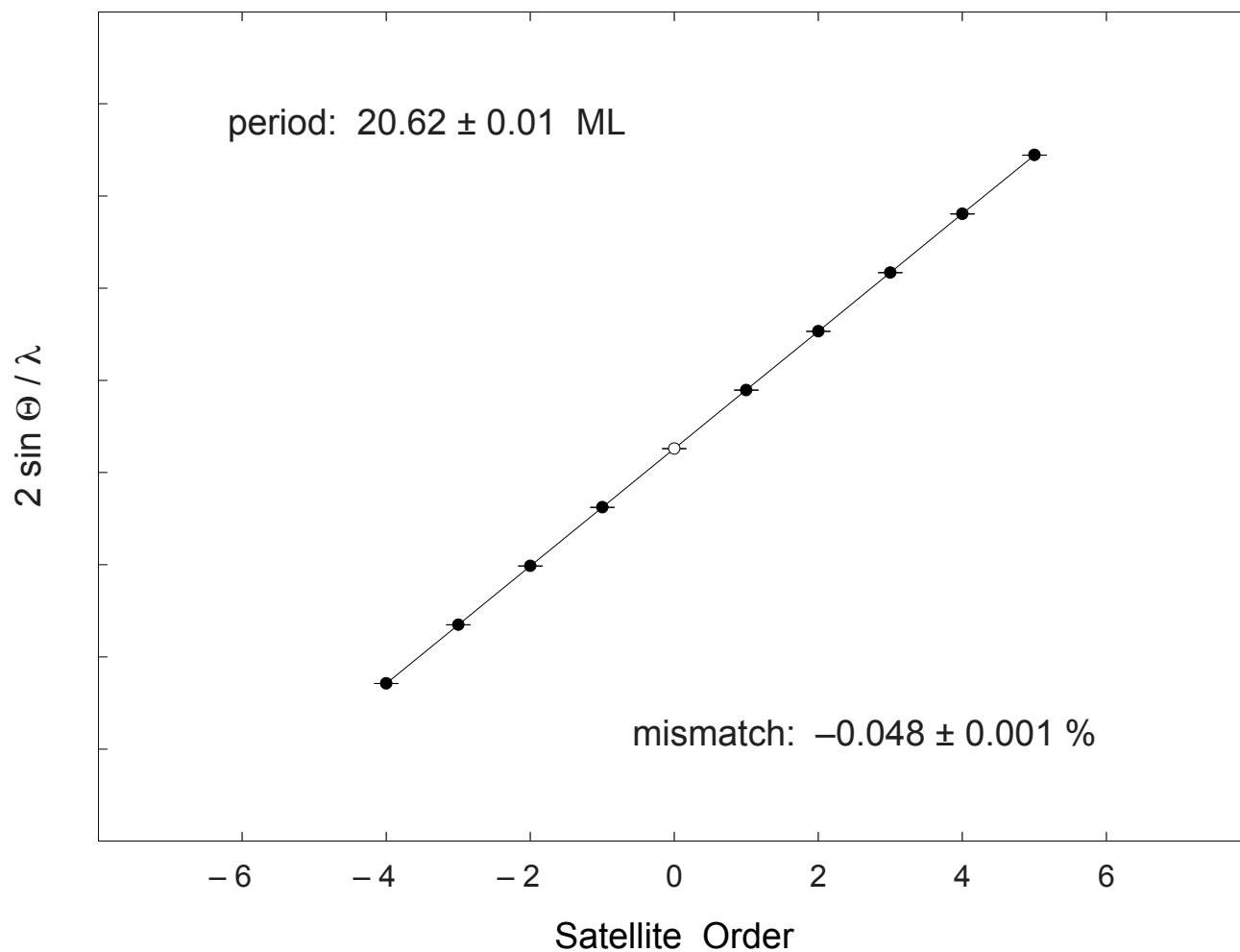
INAs / INAsSB SUPERLATTICE

HRXRD Analysis



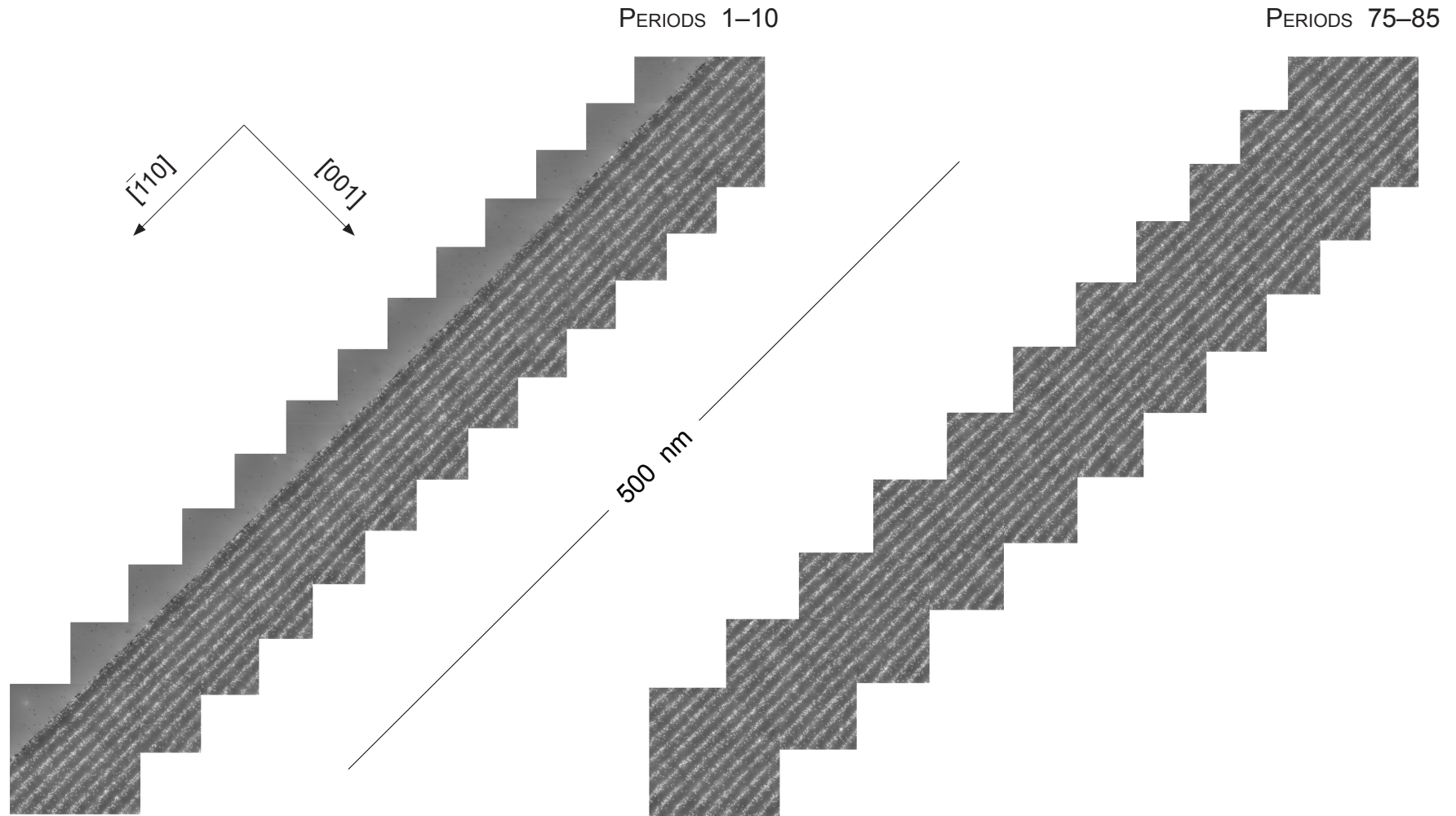
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HRXRD Analysis



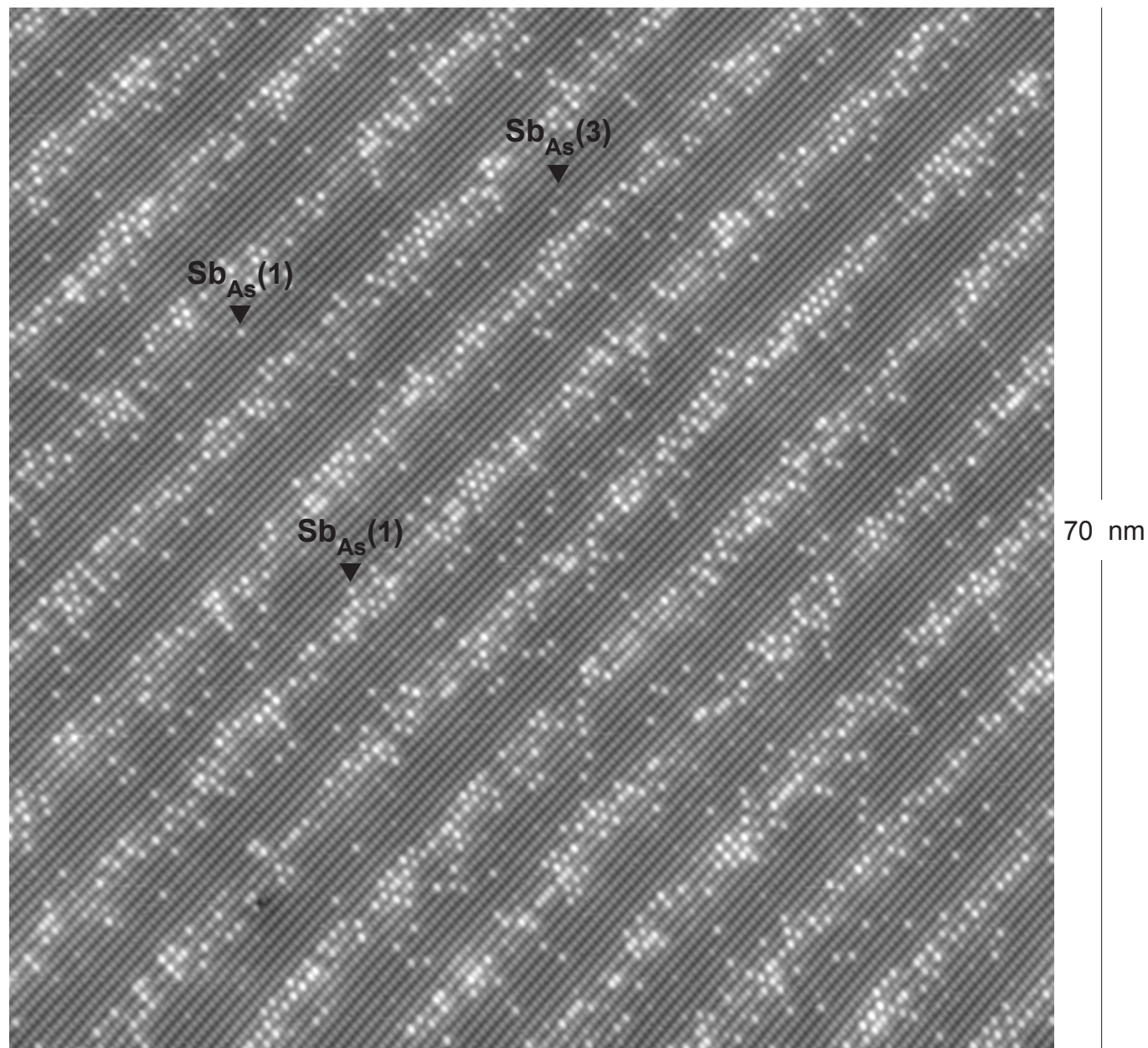
INAs / INAsSB SUPERLATTICE

Device-Scale STM Surveys

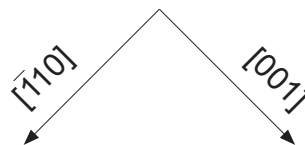


INAs / INAsSb SUPERLATTICE

Isovalent Impurity Identification



InAsSb / InAs



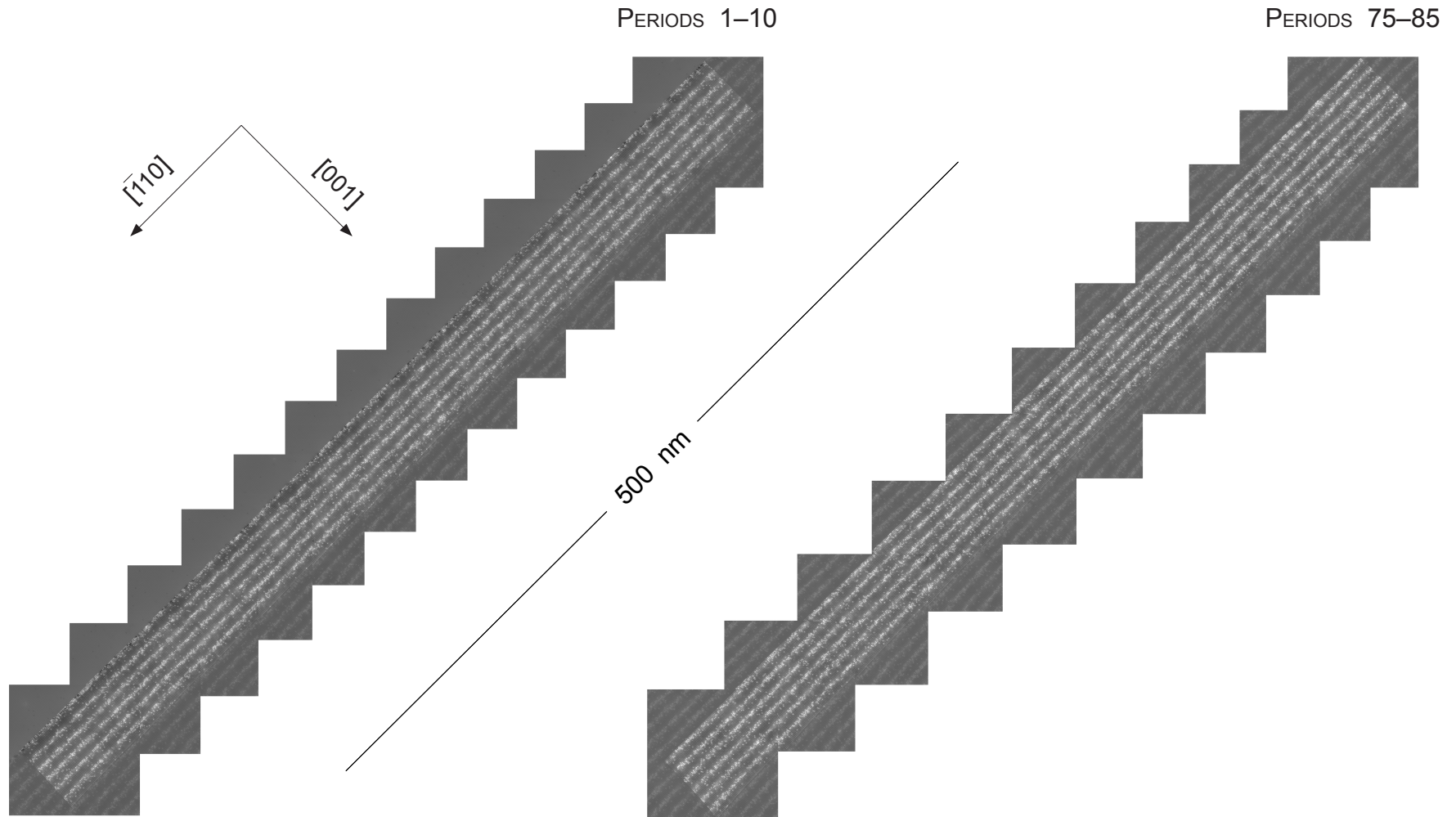
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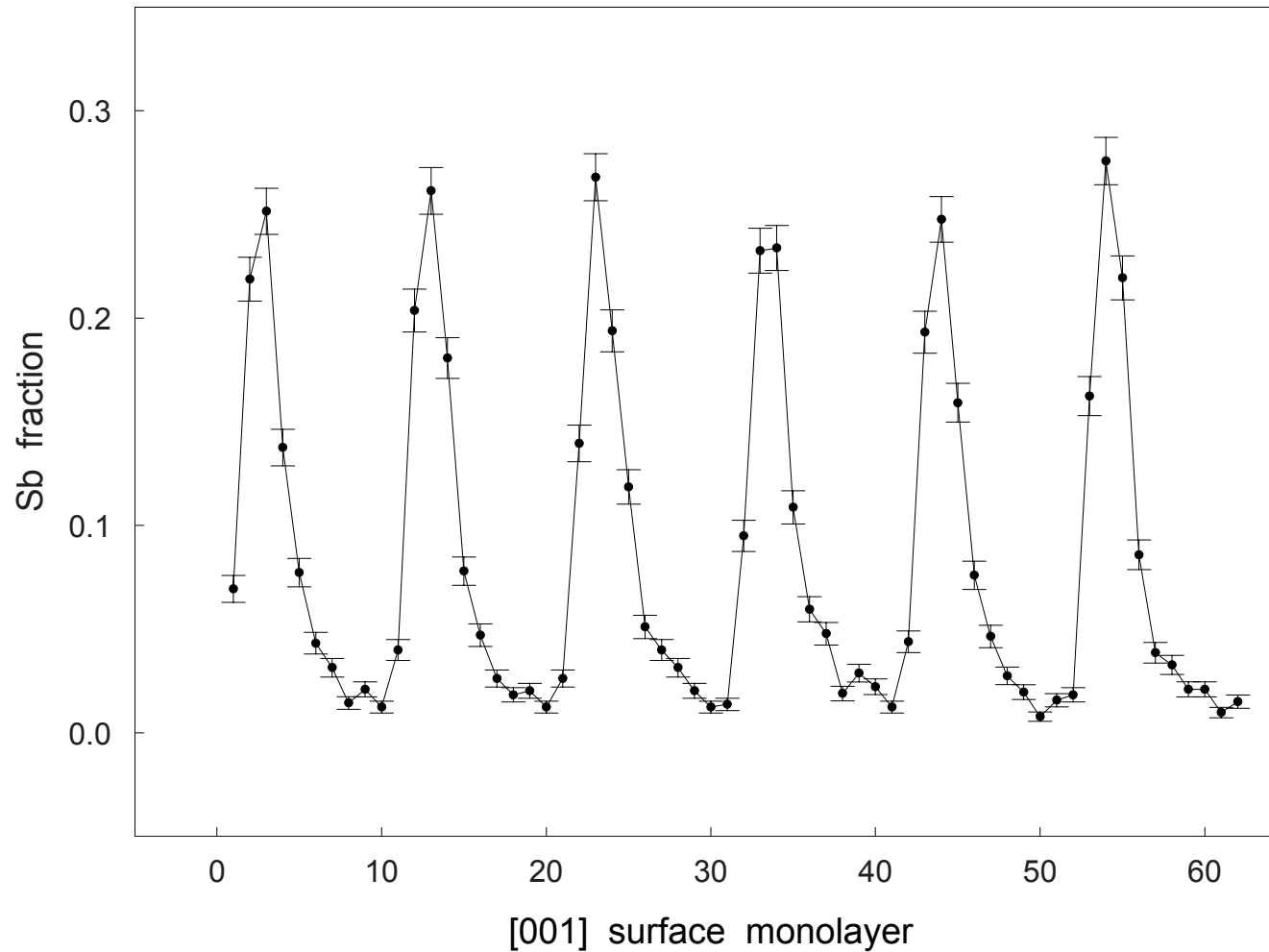
INAs / INAsSB SUPERLATTICE

Device-Scale STM Surveys



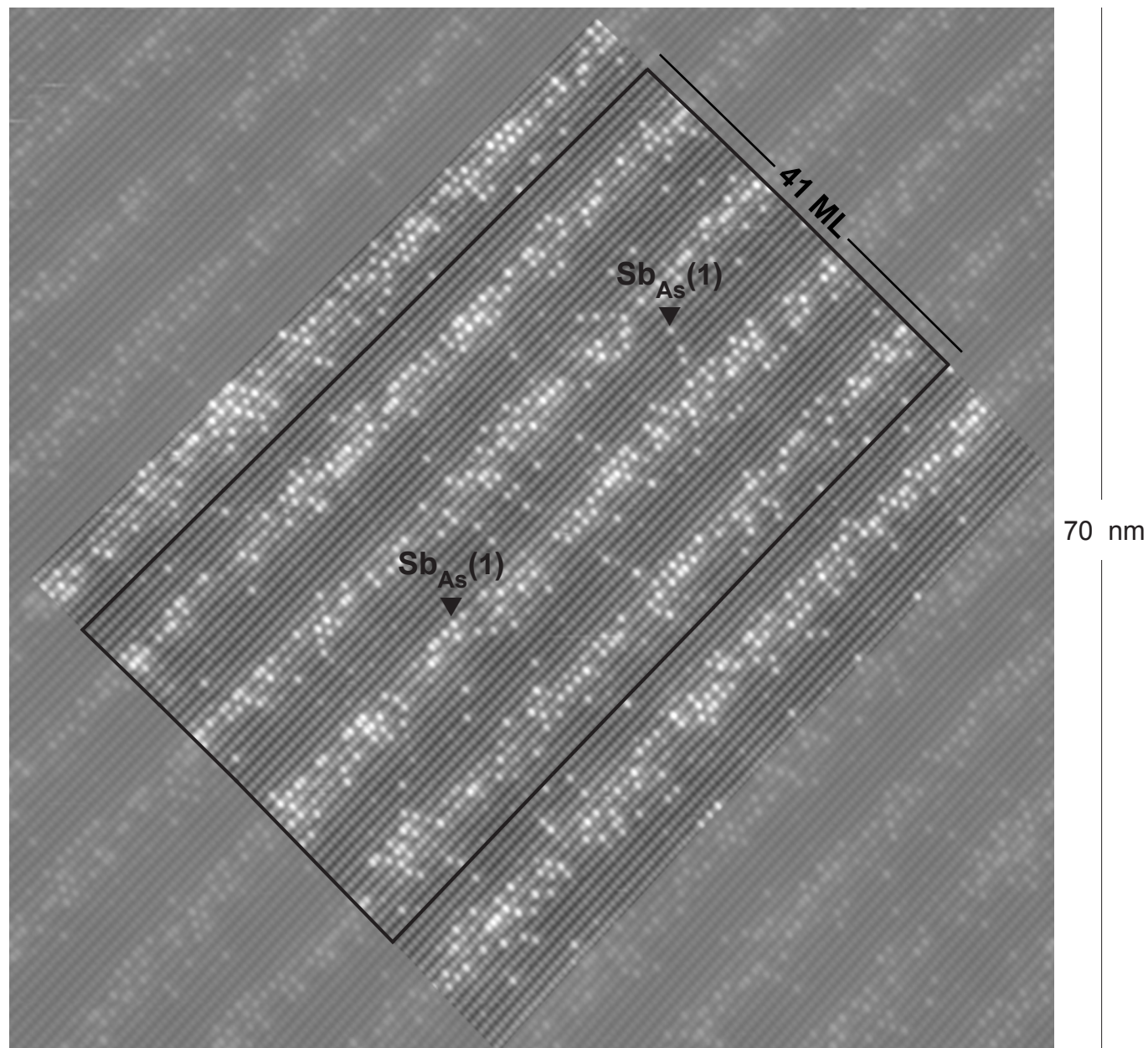
INAs / INAsSb SUPERLATTICE

Surface Antimony Profile

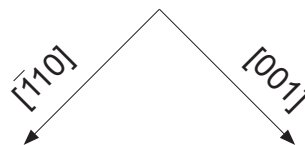


INAs / INAsSb SUPERLATTICE

Surface Period



InAsSb / InAs



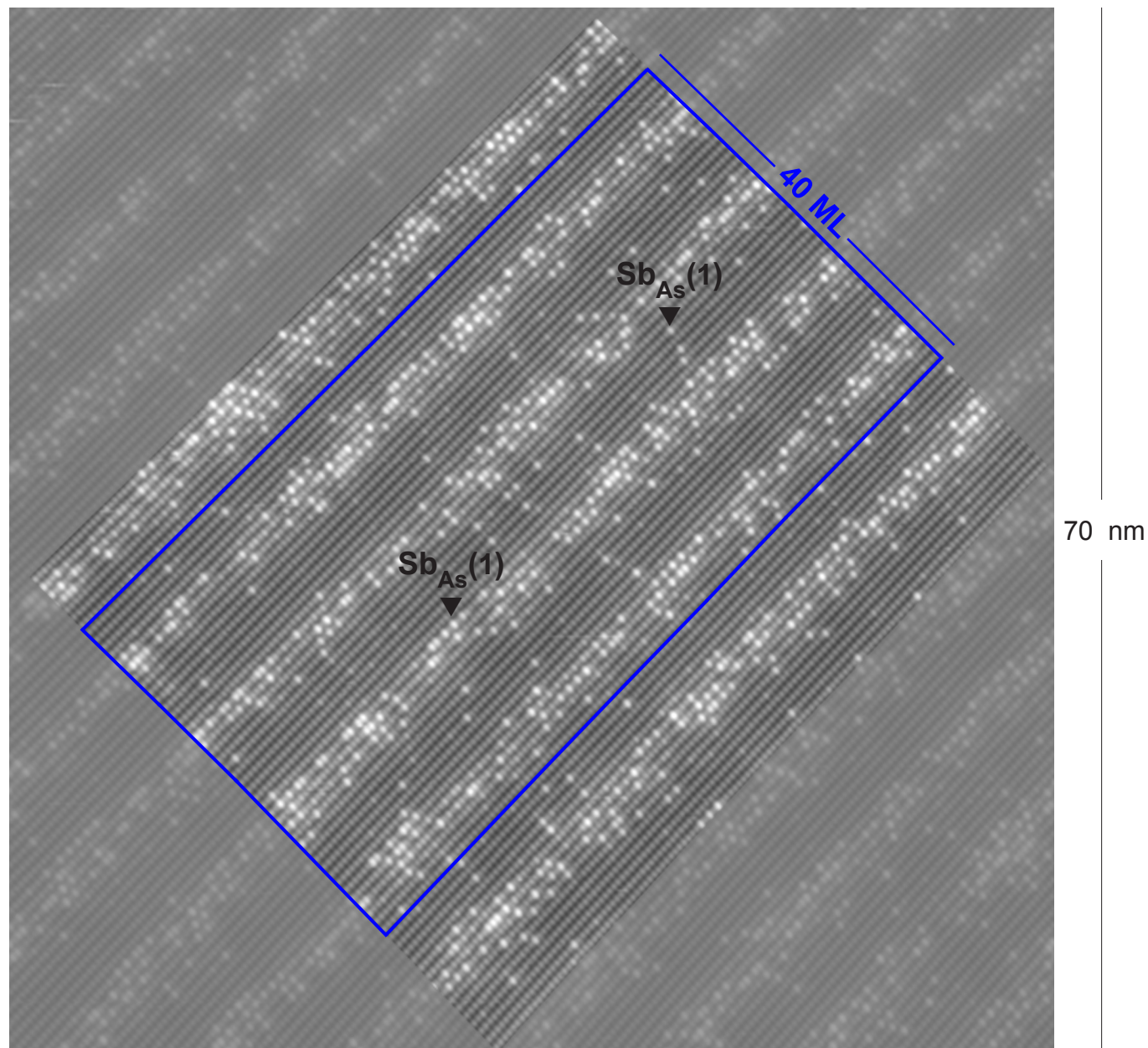
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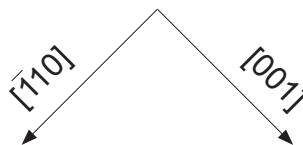
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INAs / INAsSb SUPERLATTICE

Surface Period



InAsSb / InAs



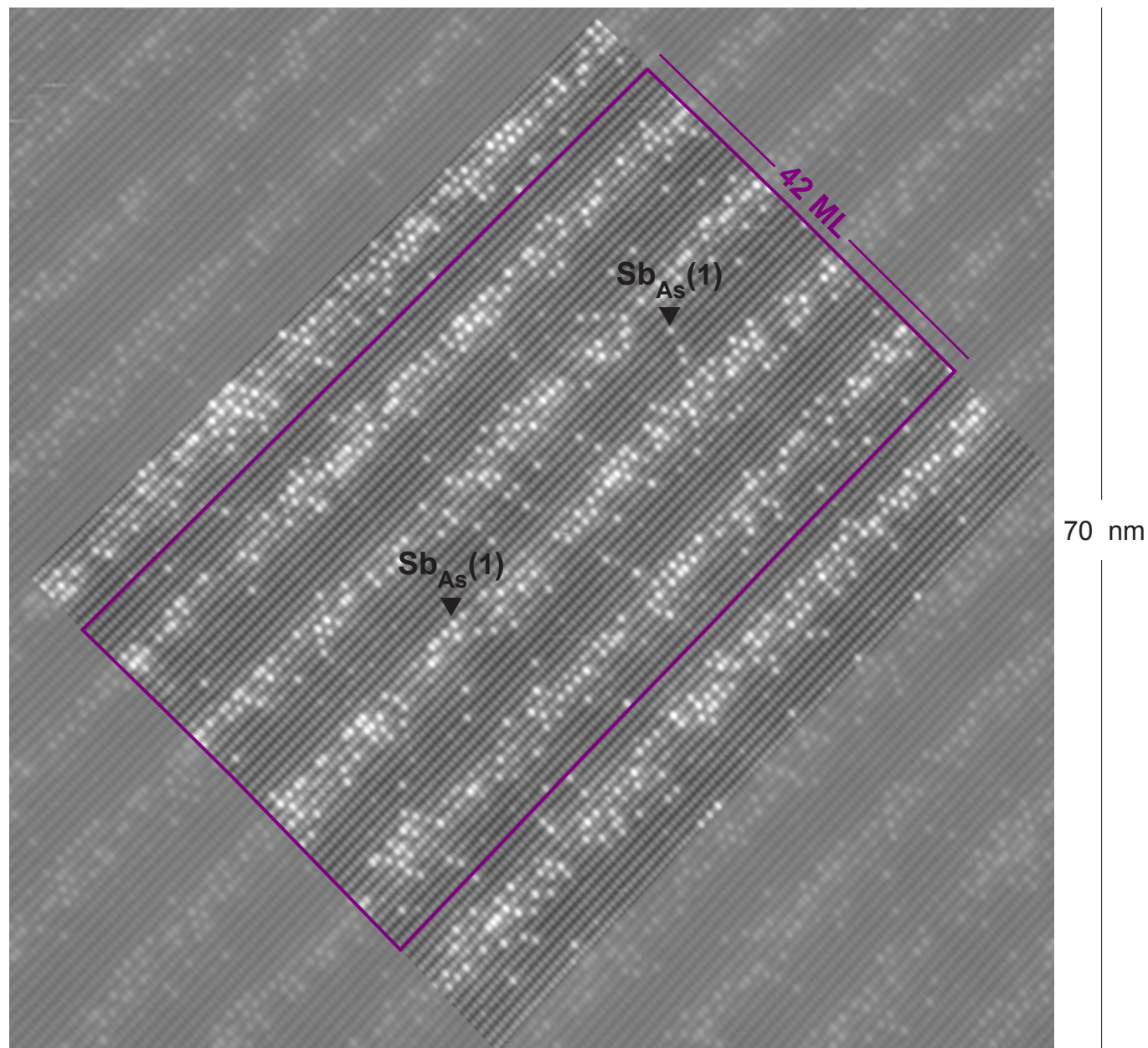
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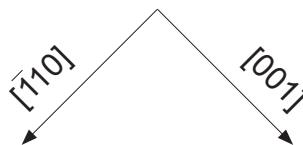
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INAs / INAsSb SUPERLATTICE

Surface Period



InAsSb / InAs



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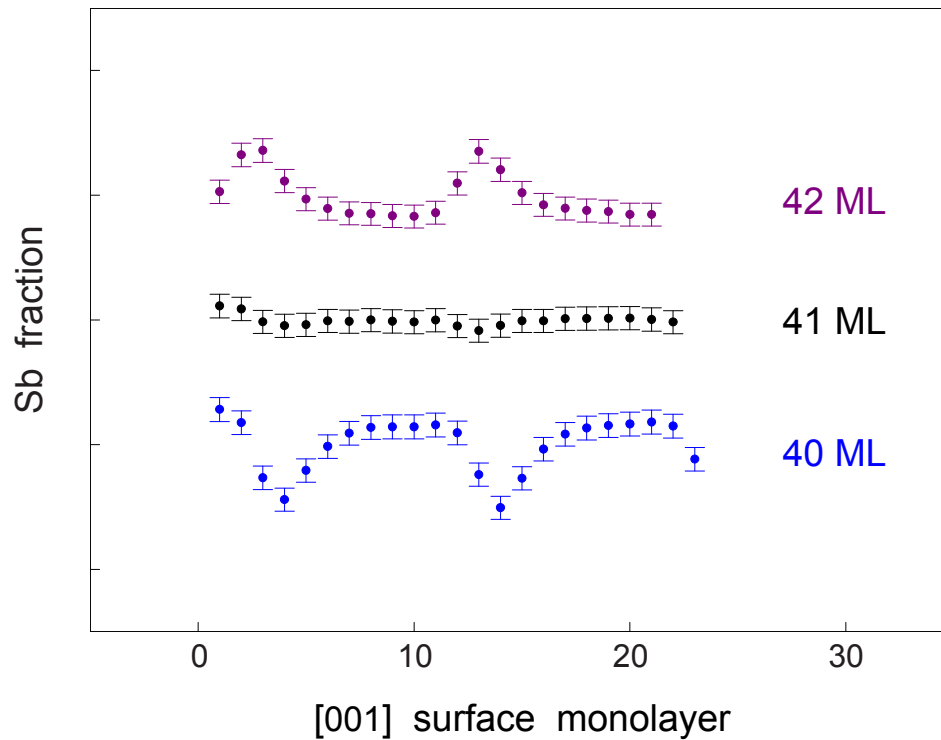


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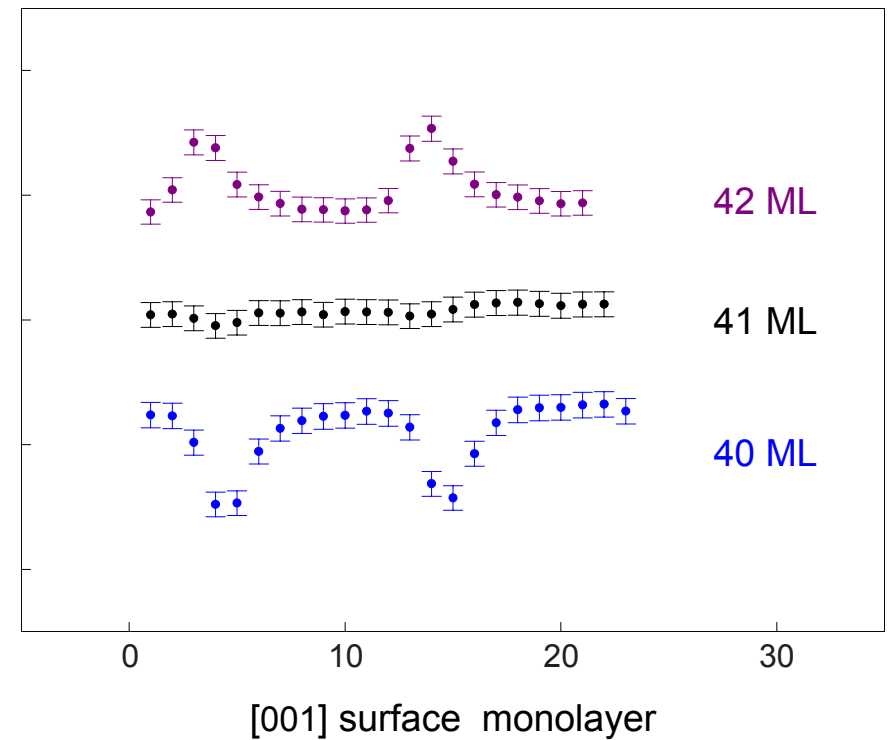
InAs / InAsSb SUPERLATTICE

Surface Period

sliding average periods 7–12

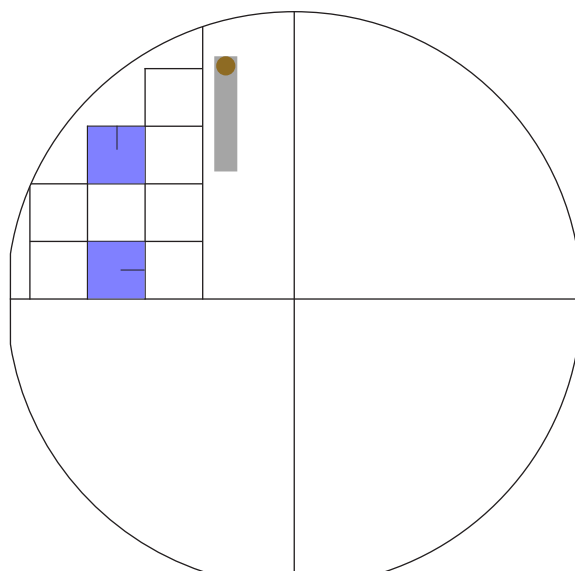
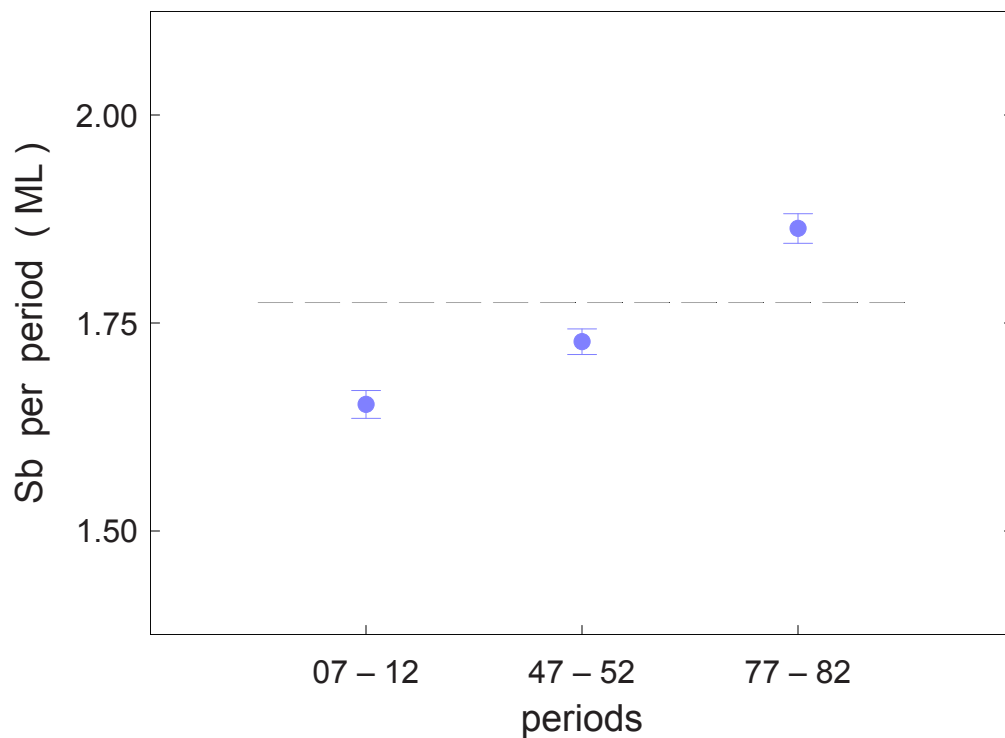


sliding average periods 77–82



INAs / INAsSb SUPERLATTICE

Antimony per Bulk Period



[110]



[$\bar{1}\bar{1}0$]



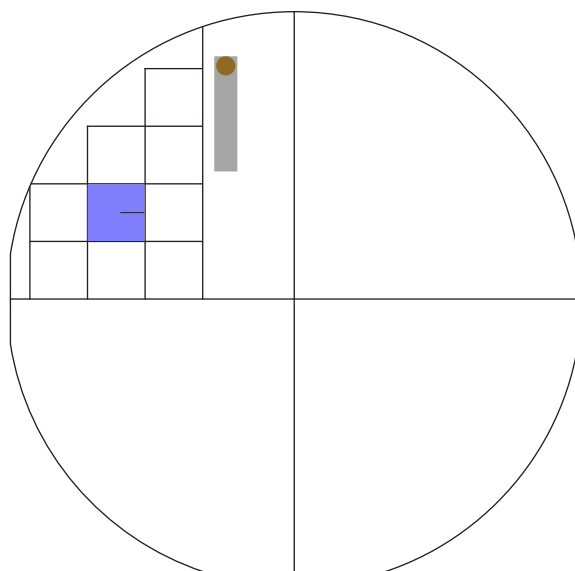
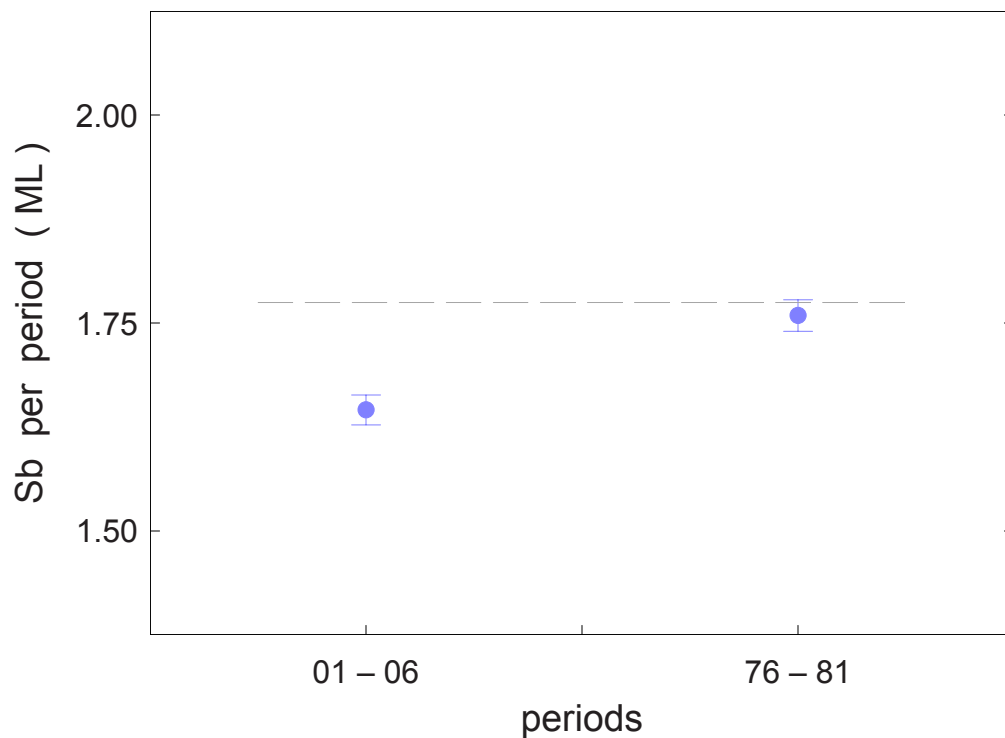
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INAs / INAsSb SUPERLATTICE

Antimony per Bulk Period



[110]



[$\bar{1}\bar{1}0$]

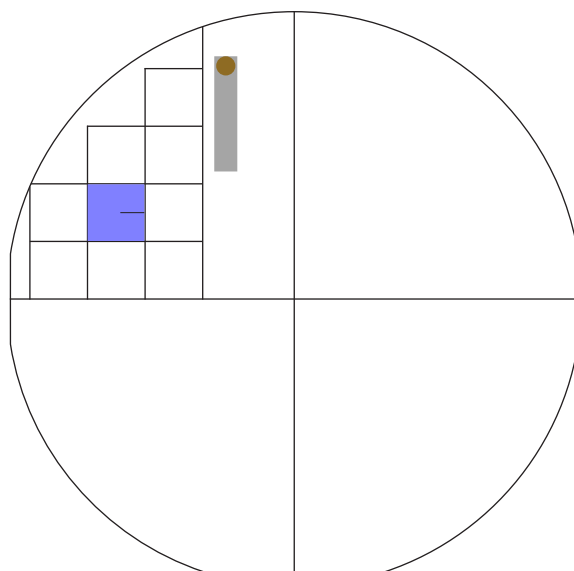
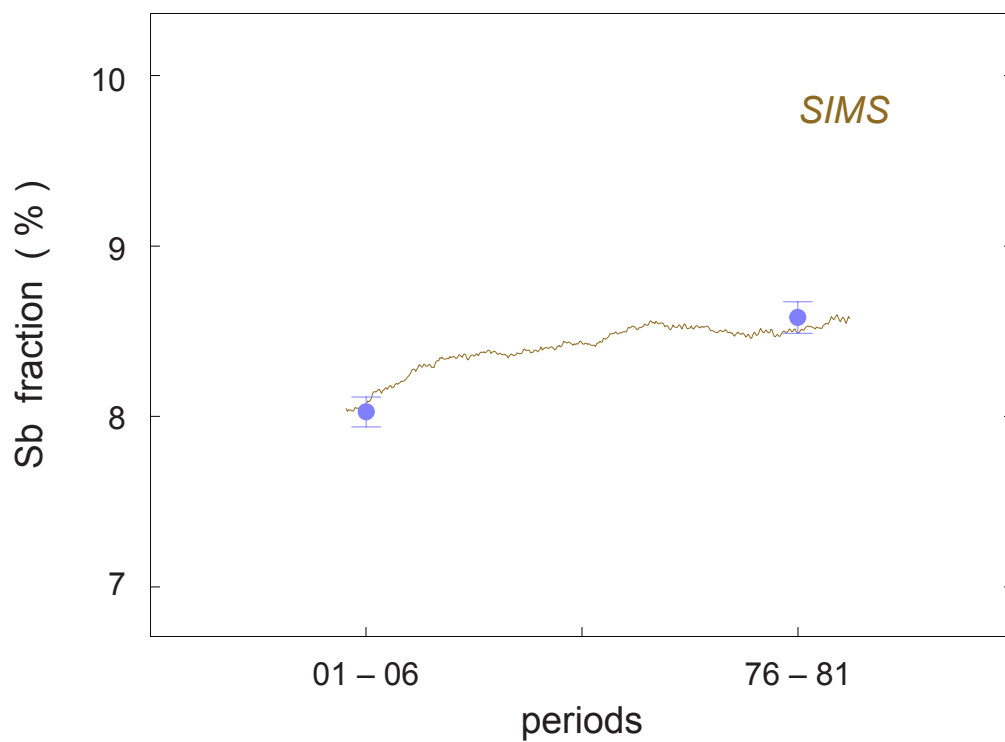


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INAs / INAsSb SUPERLATTICE

Antimony Concentration



[110]



[$\bar{1}\bar{1}$ 0]



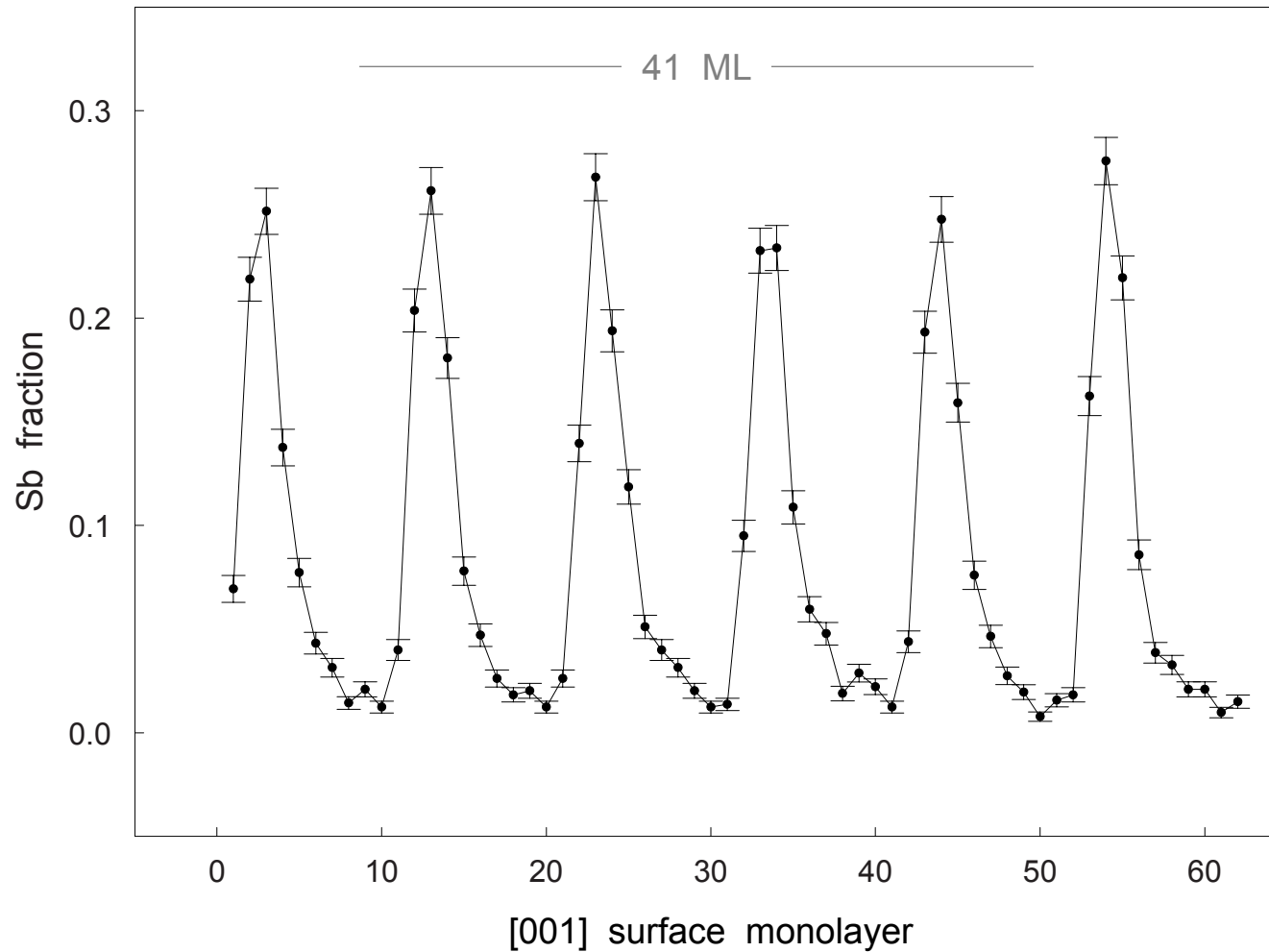
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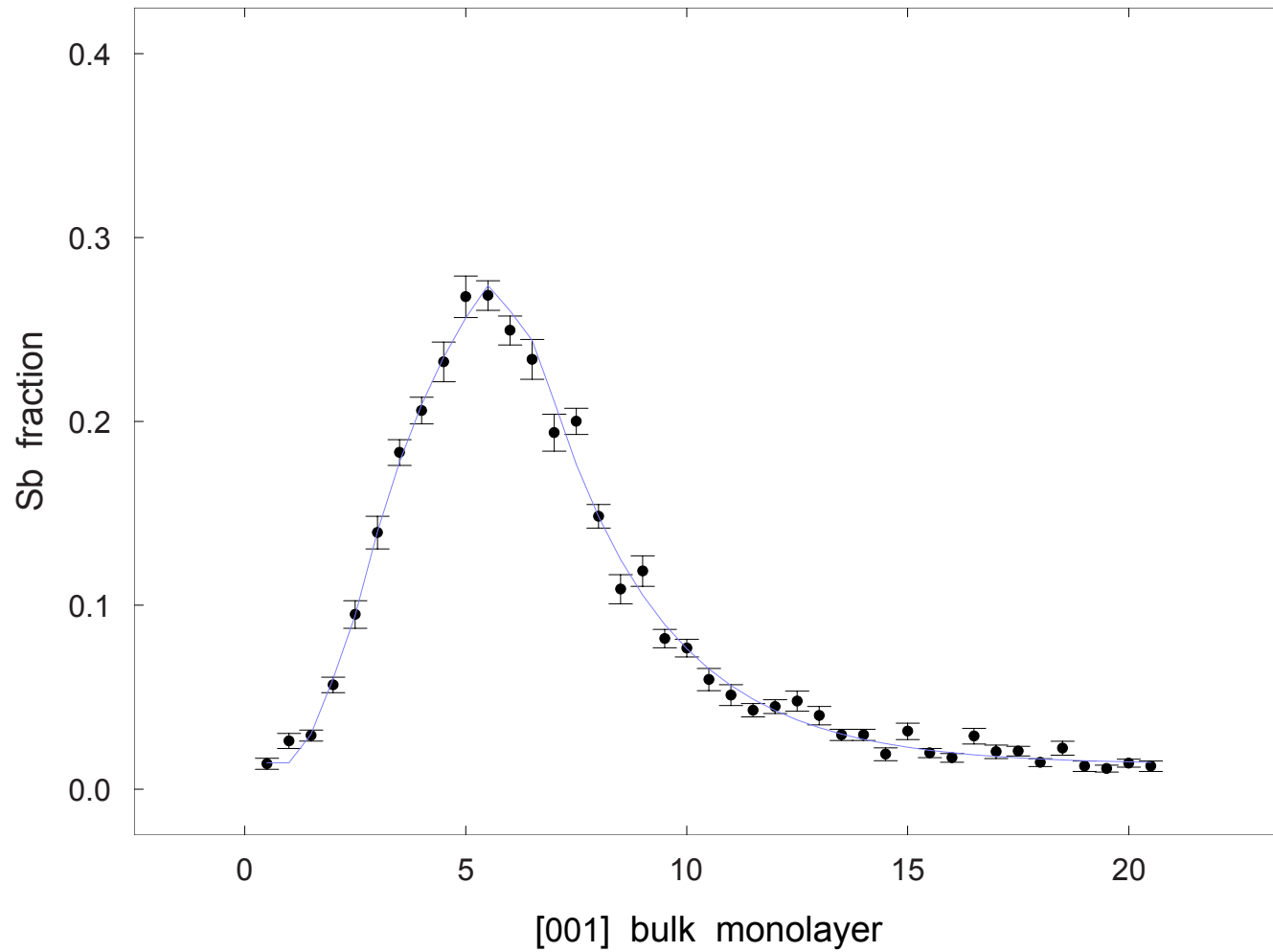
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Surface Antimony Profile



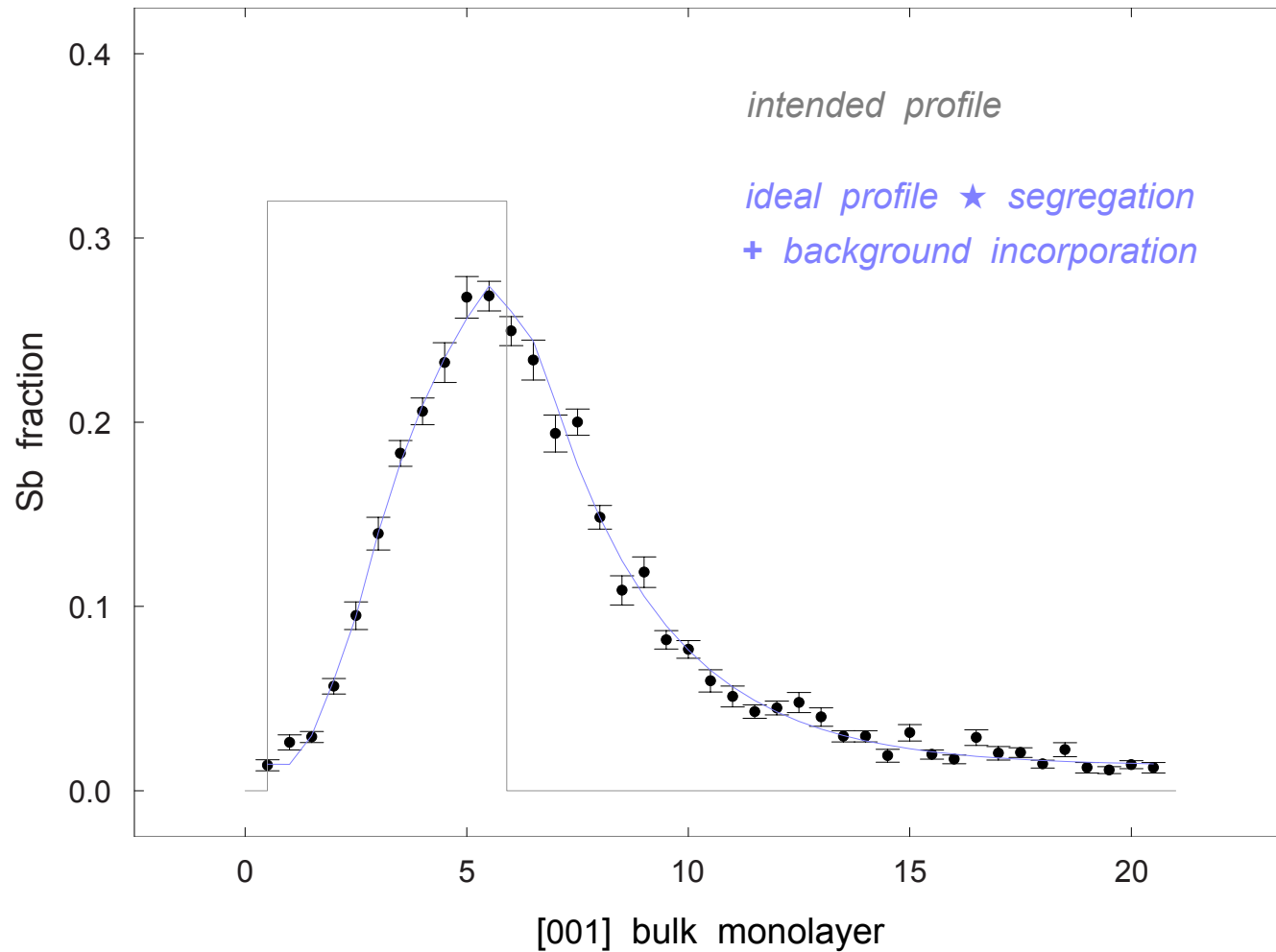
INAs / INAsSb SUPERLATTICE

Bulk Antimony Profile



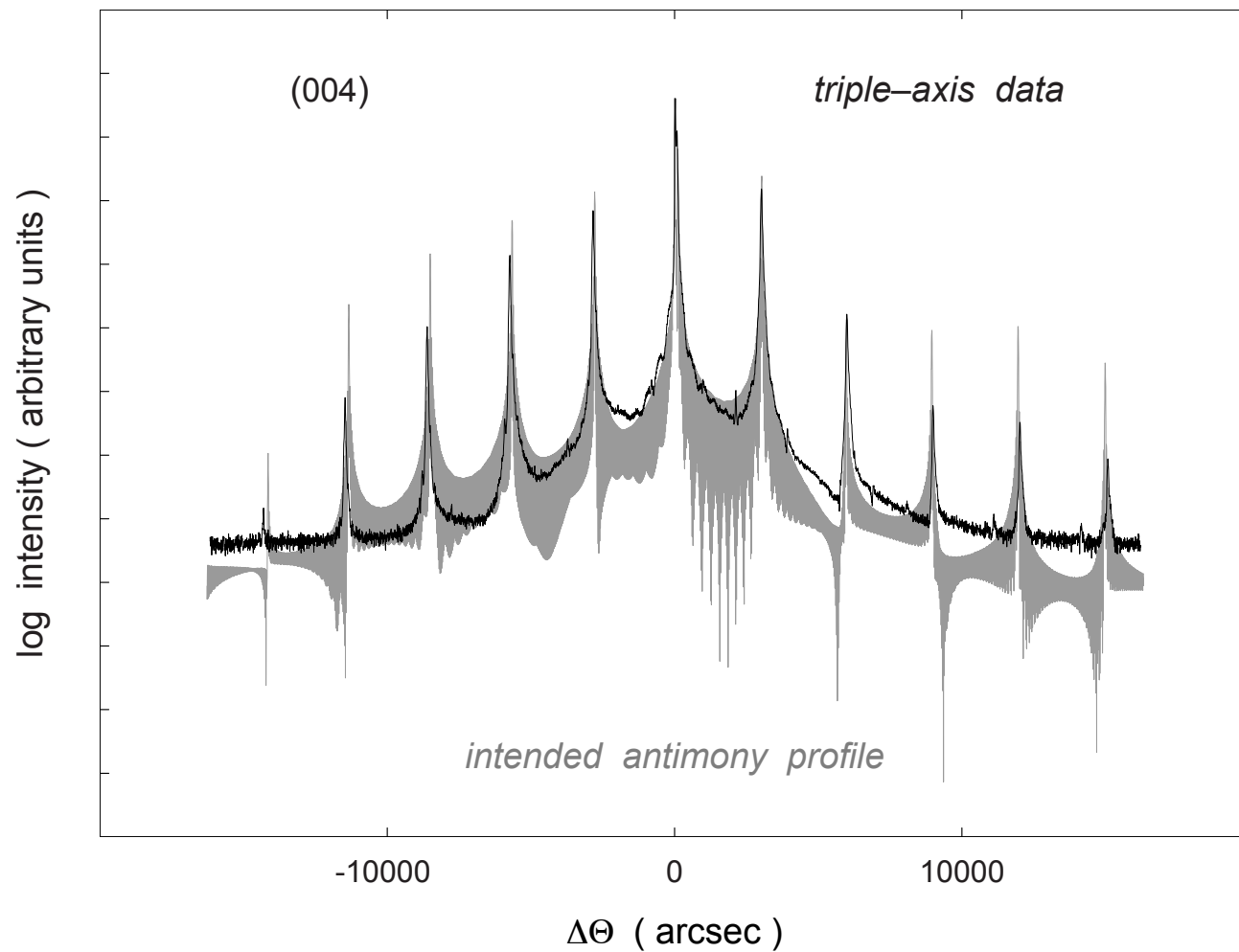
INAs / INAsSb SUPERLATTICE

Bulk Antimony Profile



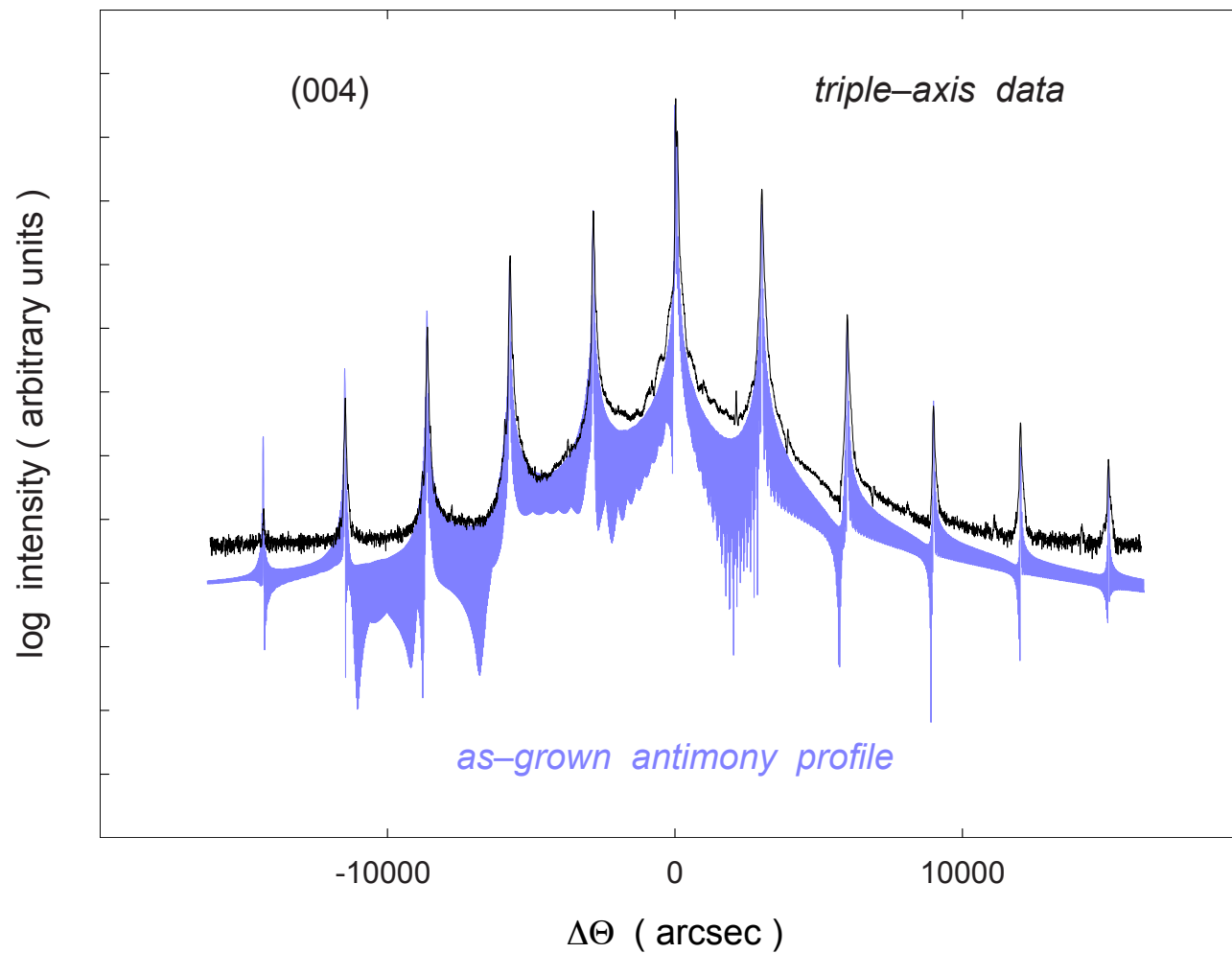
InAs / InAsSb SUPERLATTICE

Experimental vs Intended HRXRD



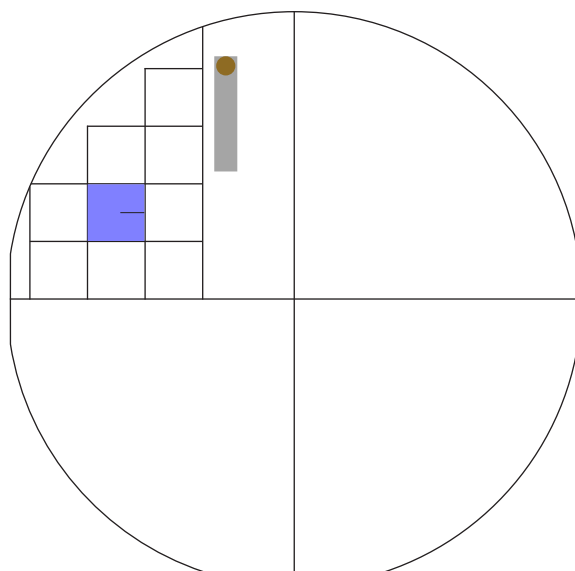
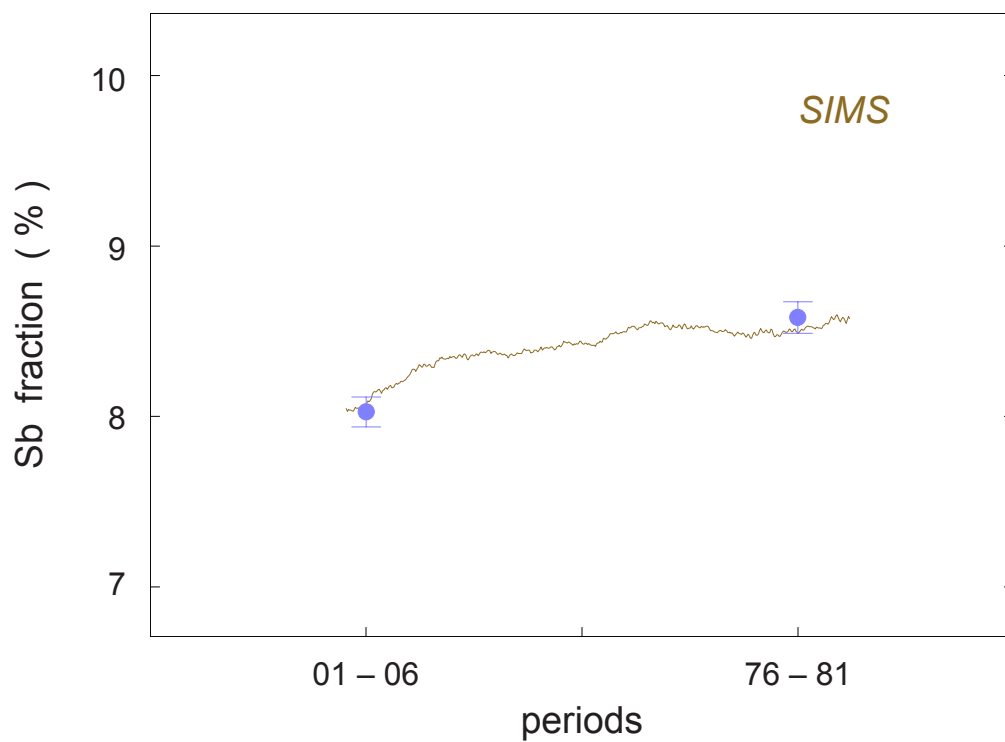
INAs / INAsSb SUPERLATTICE

Experimental vs STM-Derived HRXRD

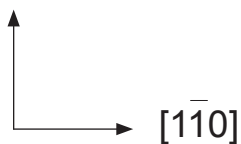


INAs / INAsSb SUPERLATTICE

Antimony Concentration



[110]

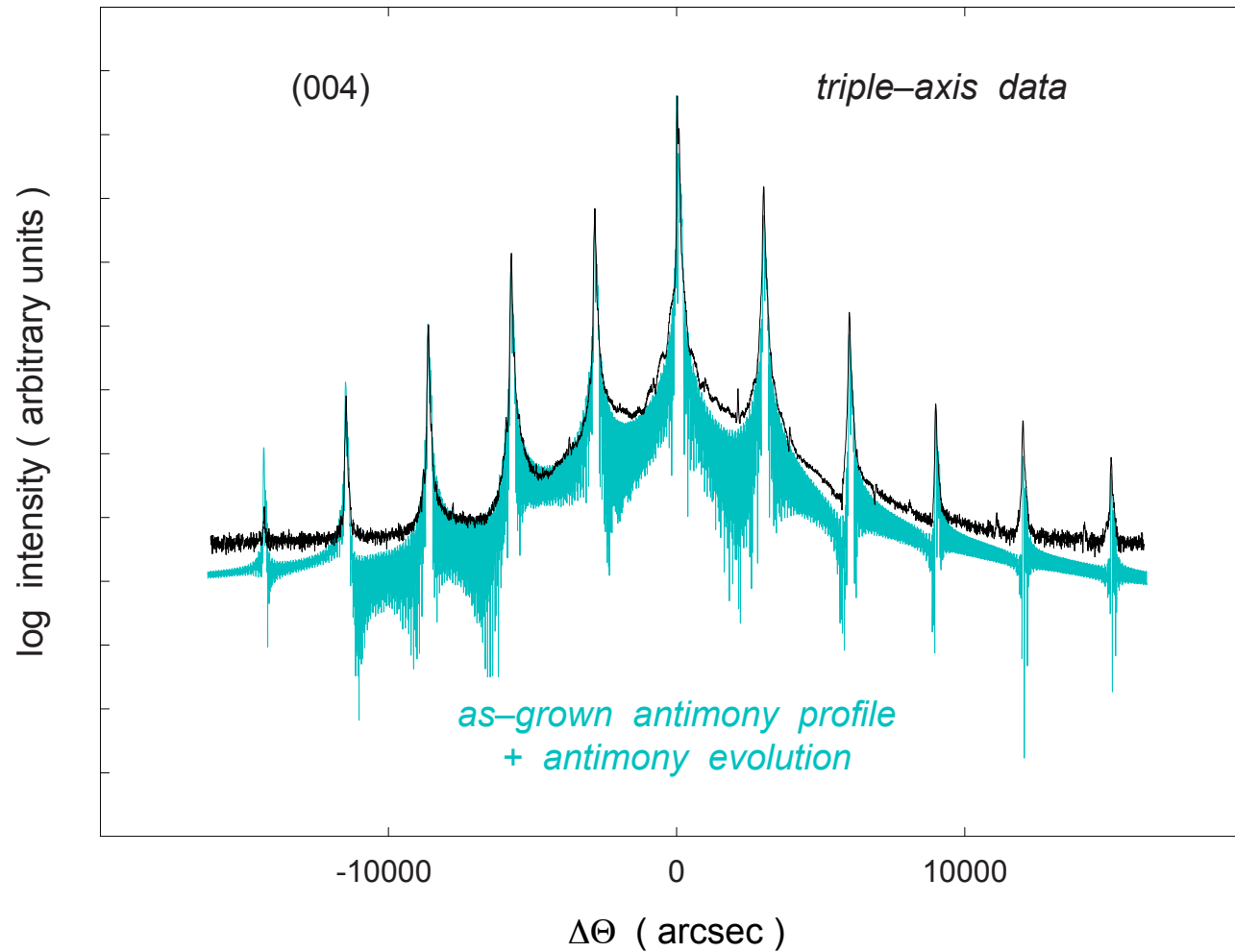


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Experimental vs STM-Derived HRXRD



SUMMARY

INAs / INAsSB TYPE-II SLS

- as-grown HRXRD differs from design HRXRD
- confinement depends on as-grown antimony distribution

APPROACH

- characterize typical device structure with STM
- measure antimony content of select superlattice periods
- reconstruct as-grown antimony profile
- compare STM-derived HRXRD predictions with experiment

CONCLUSIONS

- total antimony per period changes as growth evolves
- as-grown composition profile reflects antimony segregation and background incorporation
- STM profiles provide excellent match to observed HRXRD peak intensities
- expect STM measurements have similar predictive value for superlattice optical and electronic properties