

Growing LaRuO₃/LaAlO₃ Quantum Anomalous Hall Insulators

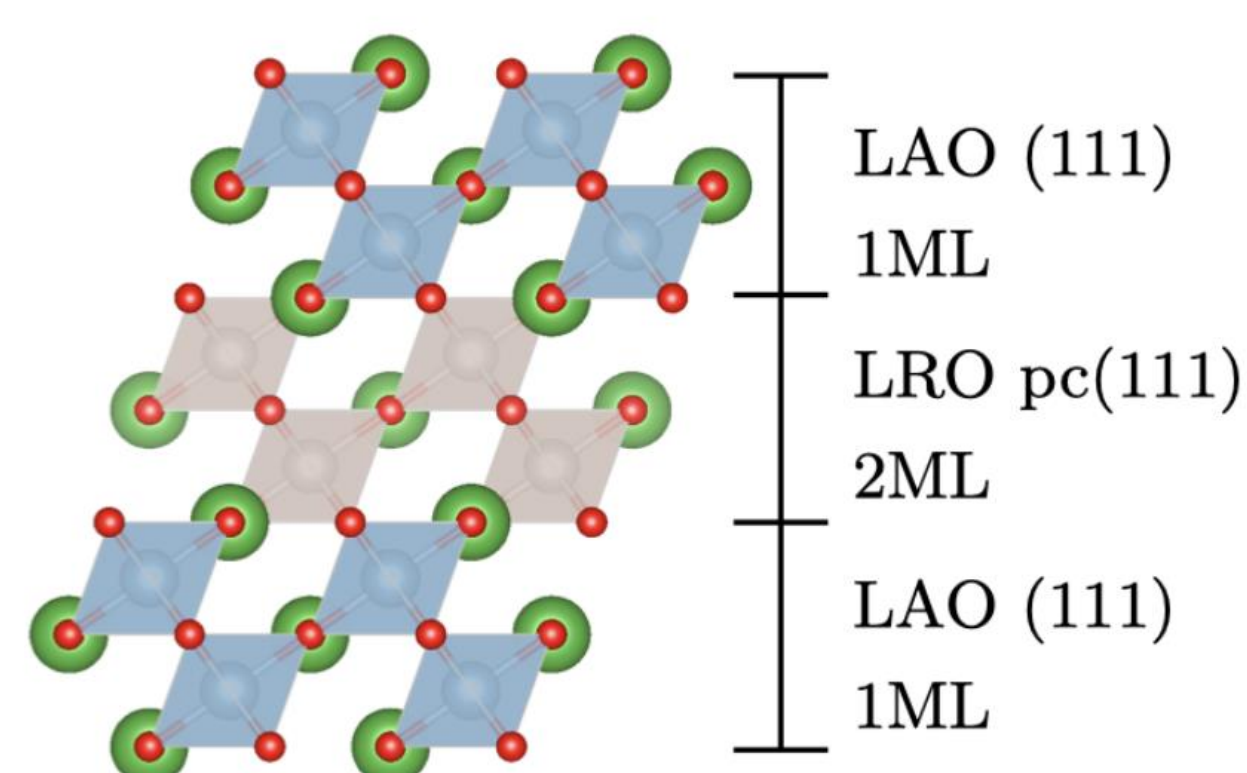
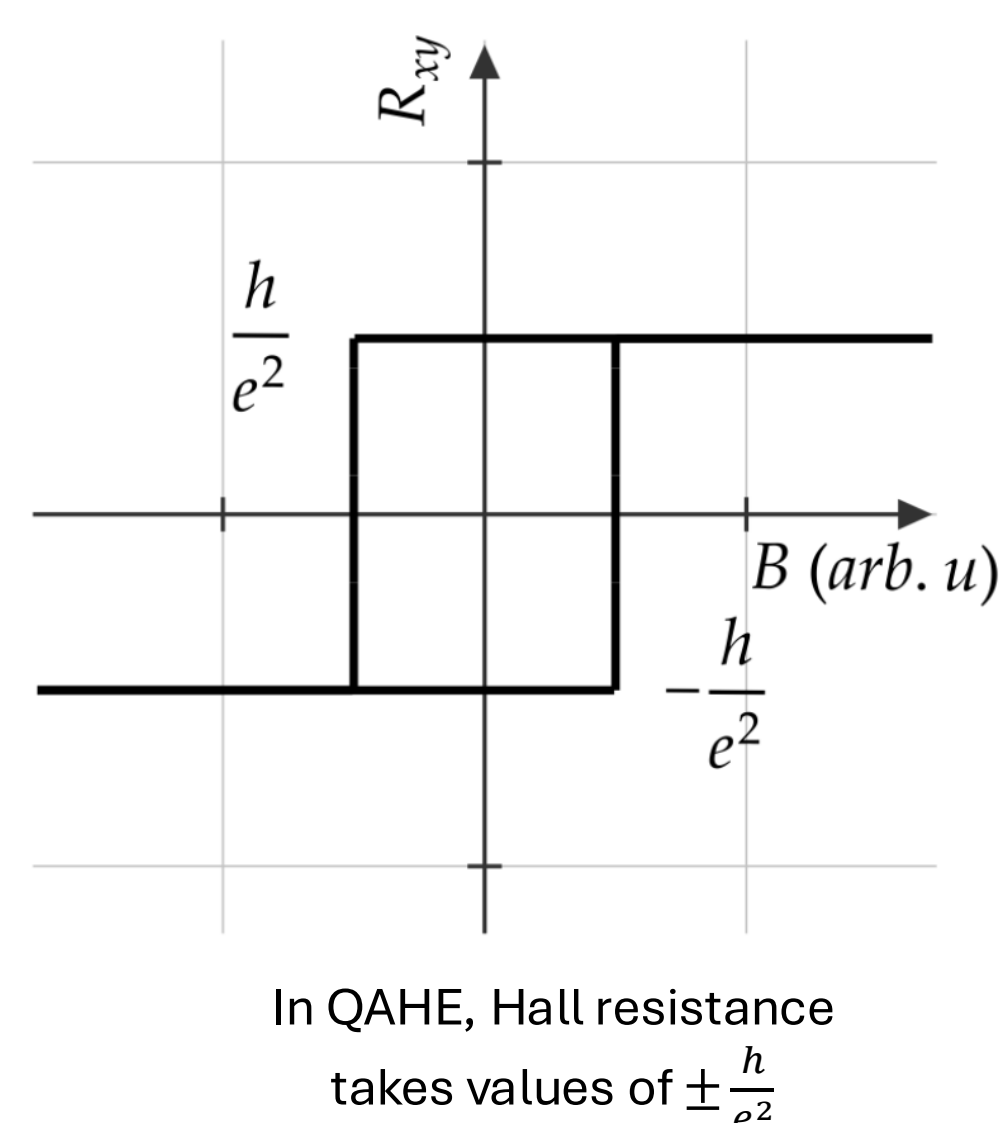
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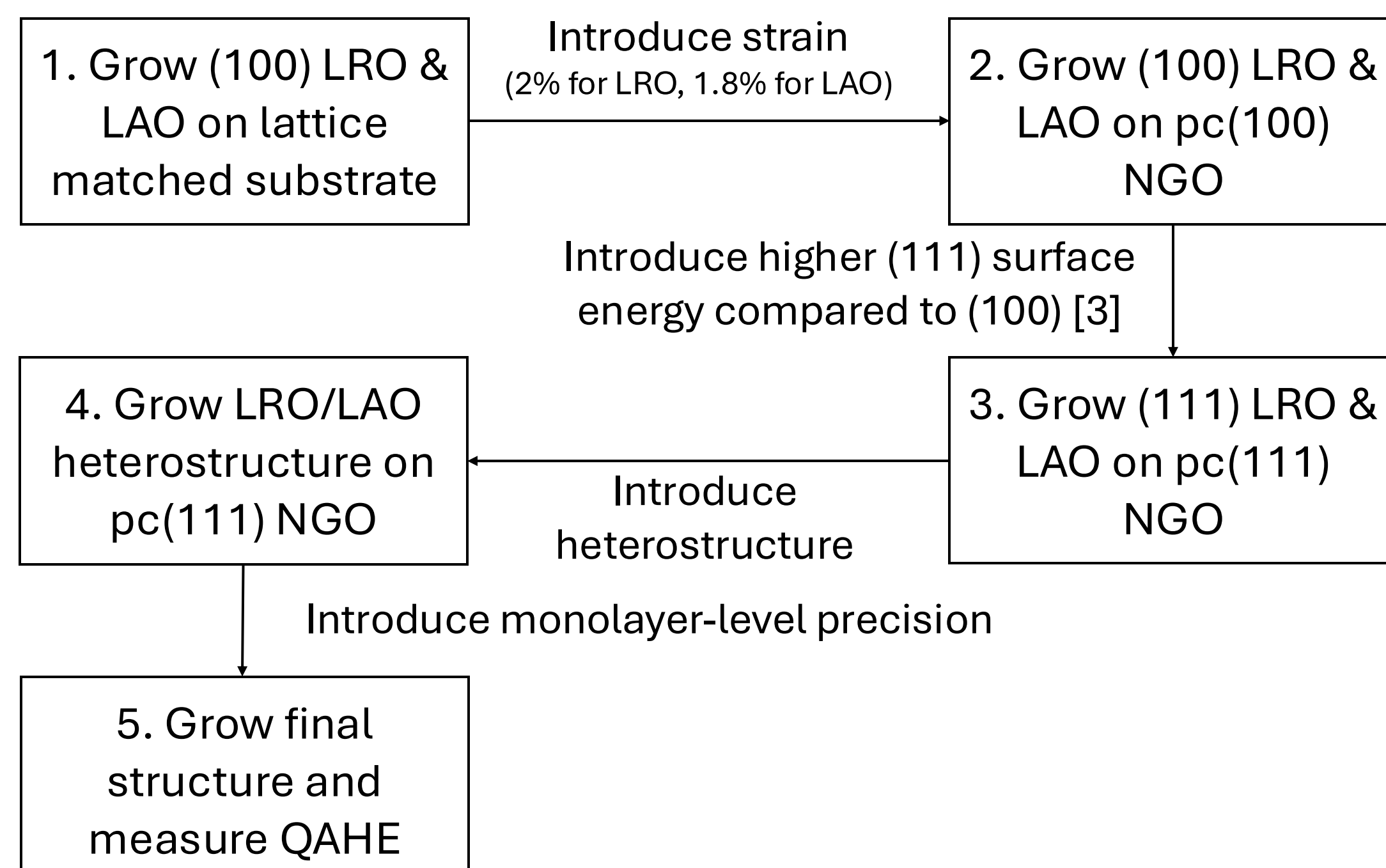
Introduction

- Quantum anomalous Hall effect (QAHE) is a quantized Hall effect that occurs in certain materials even without an applied magnetic field
- Köksal et al. and Guo et al. [1,2] predicted QAHE in LaRuO₃ (LRO) / LaAlO₃ (LAO) sandwich heterostructure using density functional theory
- Our goal: Fabricate LRO/LAO heterostructure using molecular-beam epitaxy (MBE) and measure QAHE



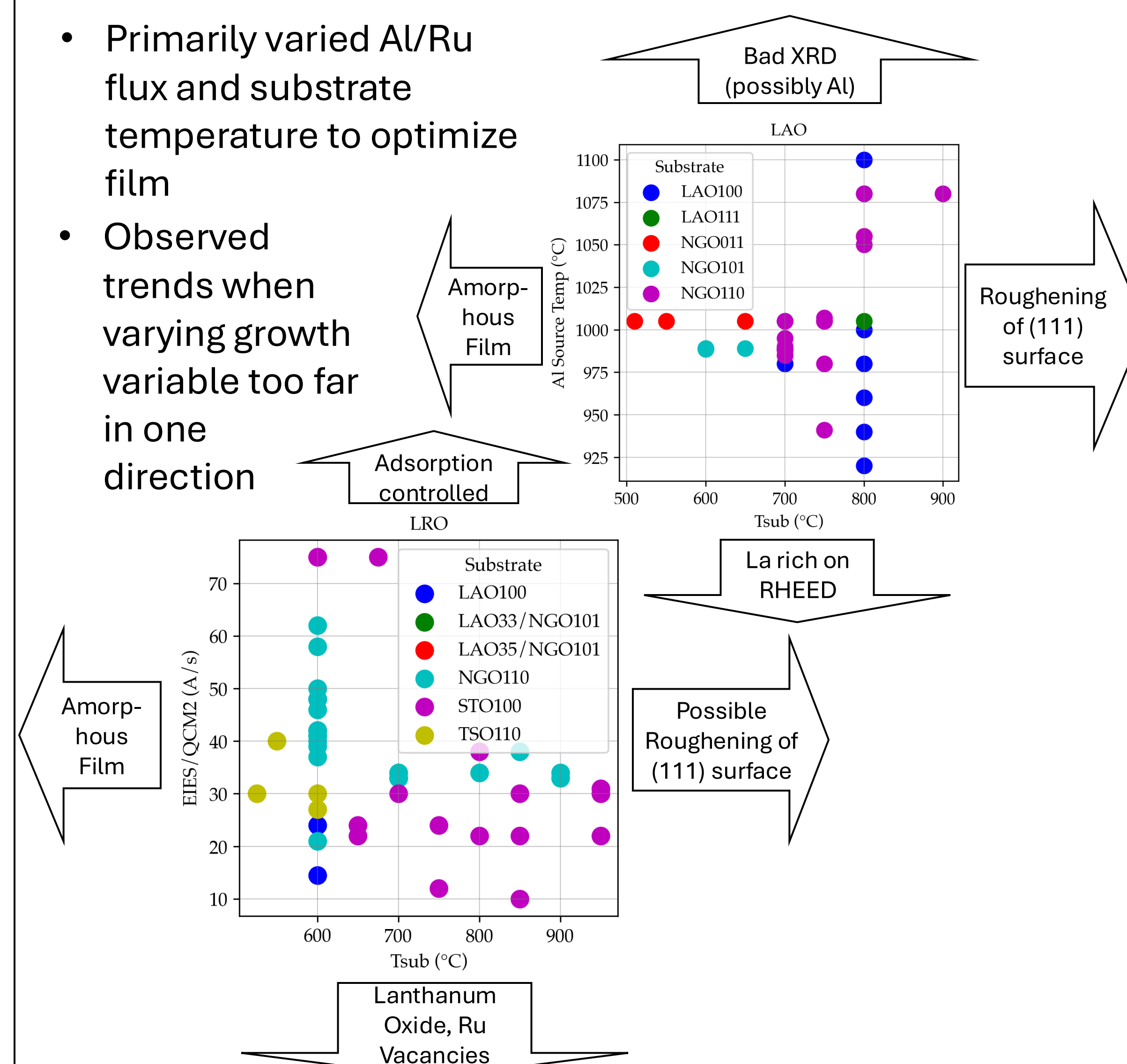
Growth Plan

- To minimize number of growth difficulties addressed at once, split structure into several steps:



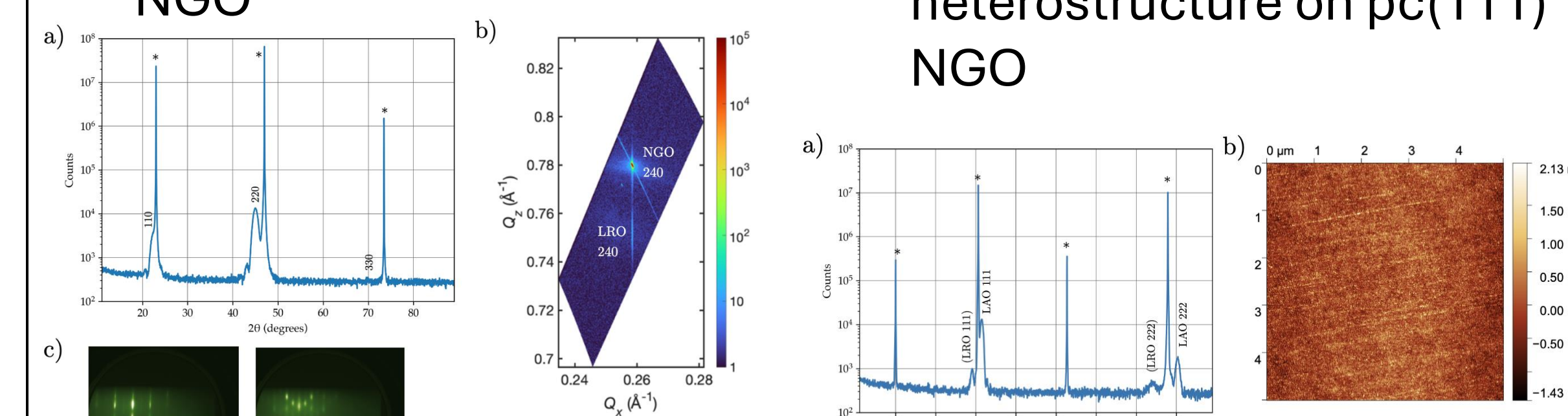
Growth Trends

- Primarily varied Al/Ru flux and substrate temperature to optimize film
- Observed trends when varying growth variable too far in one direction



Results cont.

- LRO39: best LRO on pc(100) NGO
- LRO29/LAO35: Early heterostructure on pc(111) NGO



(a) XRD: sharp film peaks at expected locations (b) RSM: film strained to substrate (c) RHEED: extra unexpected spots

(a) XRD: sharp film peaks, LAO peaks at expected locations, LRO shifted (non-stoichiometric?) (b) Spotty AFM (RMS = 0.4nm)

Conclusions & Next Steps

- We optimized growth conditions for strained (111) LAO
- Progress on growing strained pc(100) LRO and growing (111) LRO on (111) LAO
- Next Steps: continue following plan, then measure QAHE
 - To measure QAHE, fabricate Hall bar as described by Rodenbach et al. [4]

Acknowledgements

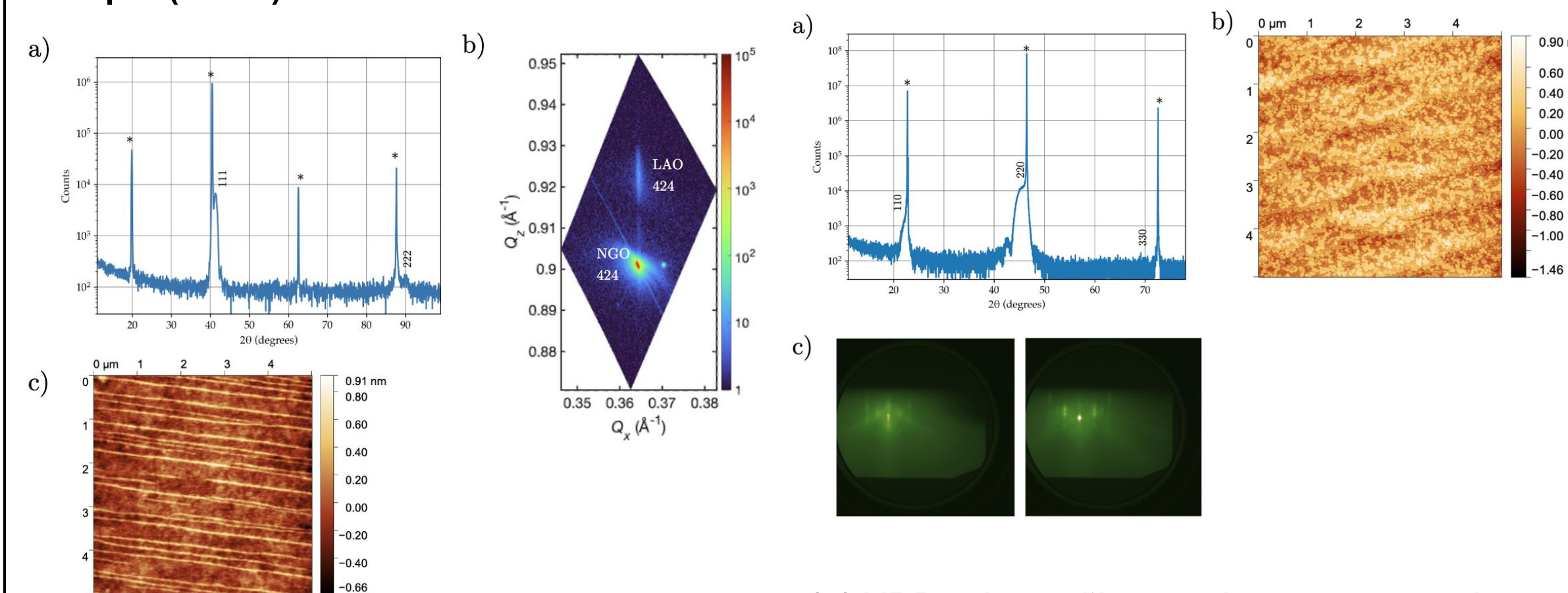
This project utilized the PARADIM facility, which is supported by the National Science Foundation under Cooperative Agreement No. DMR-2039380

References

- [1] O. Köksal et al., Sci Rep 9 (2019) 17306.
- [2] H. Guo et al., Npj Quant Mater 2 (2017) 1–8.
- [3] R.I. Eglitis, Ferroelectrics 483 (2015) 53–67.
- [4] L.K. Rodenbach et al., Phys. Rev. Appl. 18 (2022) 034008.

Results

- LAO36: best LAO on pc(111) NGO
- LRO34: best LRO on (100) STO



(a) XRD: sharp film peaks at expected locations (b) RSM: film strained to substrate (c) AFM shows low roughness (RMS = 0.2nm)

(a) XRD: sharp film peaks at expected locations (b) AFM shows low roughness (RMS = 0.25nm) (c) RHEED: Spots on ring, Kikuchi lines → high quality film