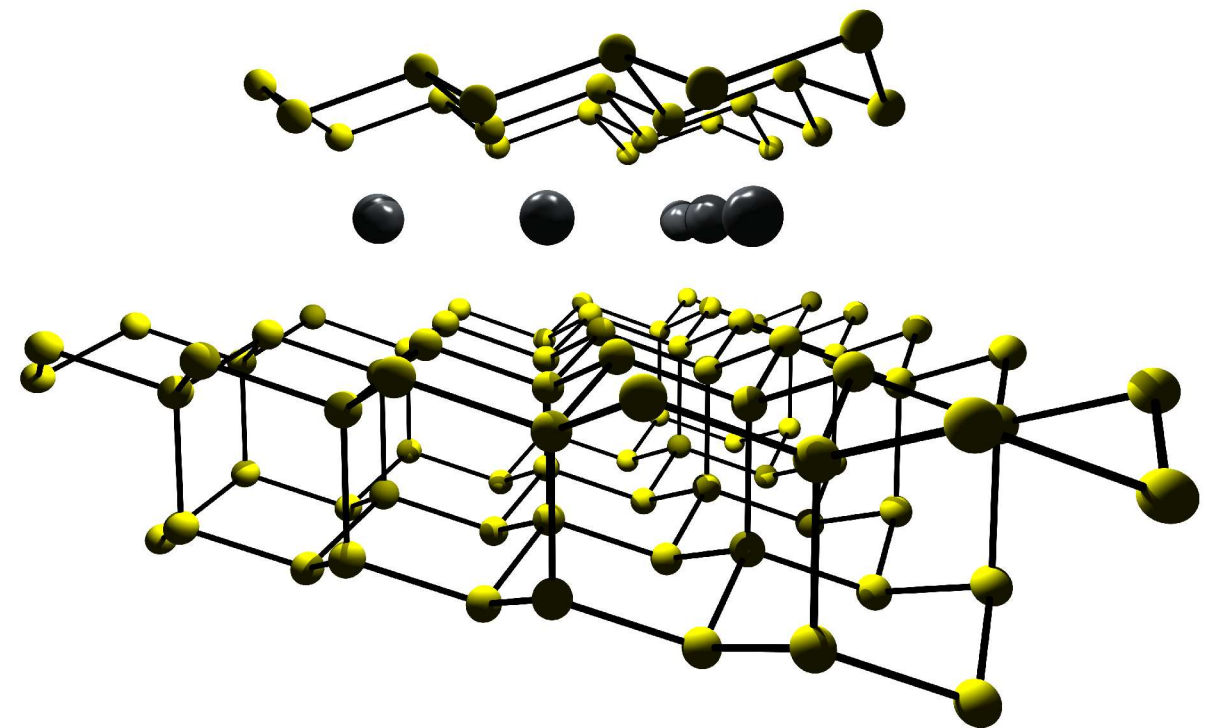


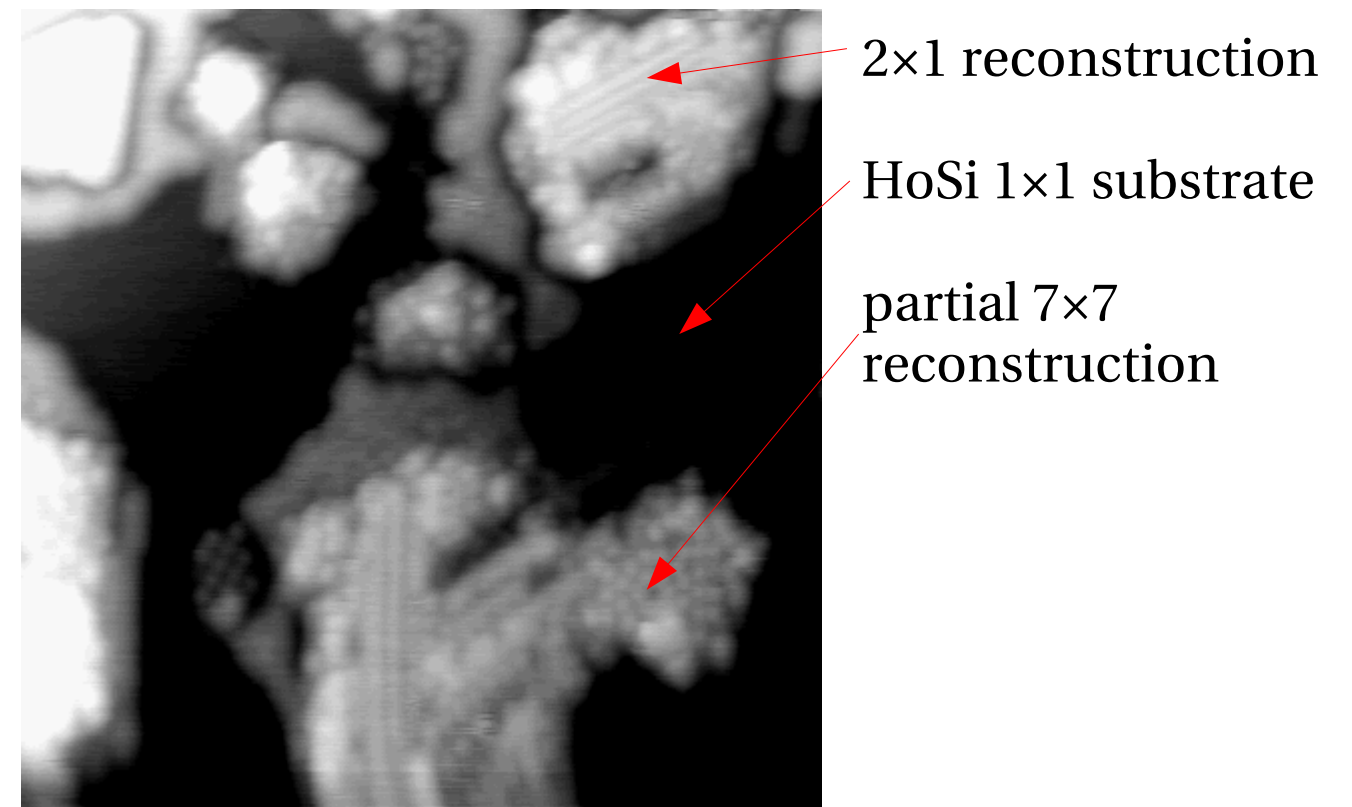
2D Rare Earths on Silicon(111)

- At monolayer coverages, the heavy trivalent rare earths (REs) form “two-dimensional” structures
- These structures are novel:
 - The topmost bilayer is structurally very similar to bulk-terminated Si(111)
 - This surface is an interesting candidate for further growth

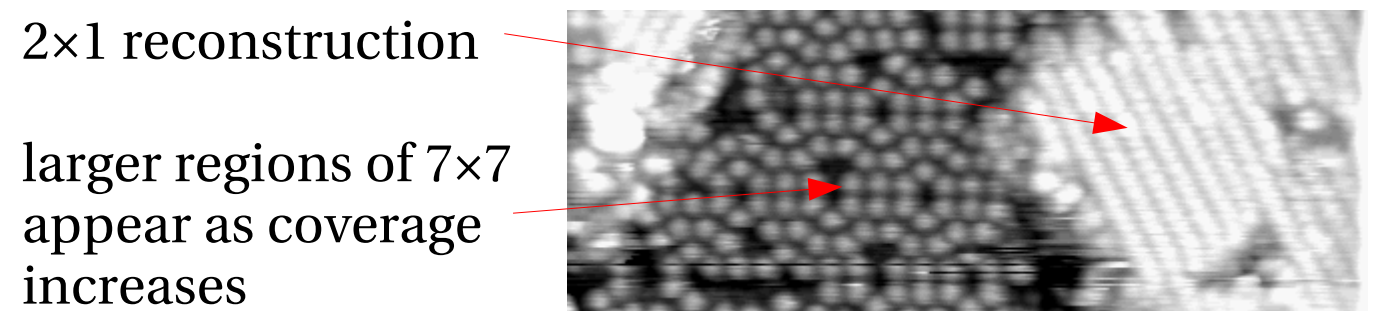


Si Growth on 2D RE Silicides

- Depositing Si on holmium silicide creates heavily islanded surfaces
- There is some initial growth directly on the HoSi substrate, but further growth is island-on-island
- The formation of silicon reconstructions (2×1 , 7×7) is observed after the first layer



SPE @ 400°C deposit of 1 bilayer Si on 2D RESi. 30 nm \times 30 nm, 2 V, 2 nA



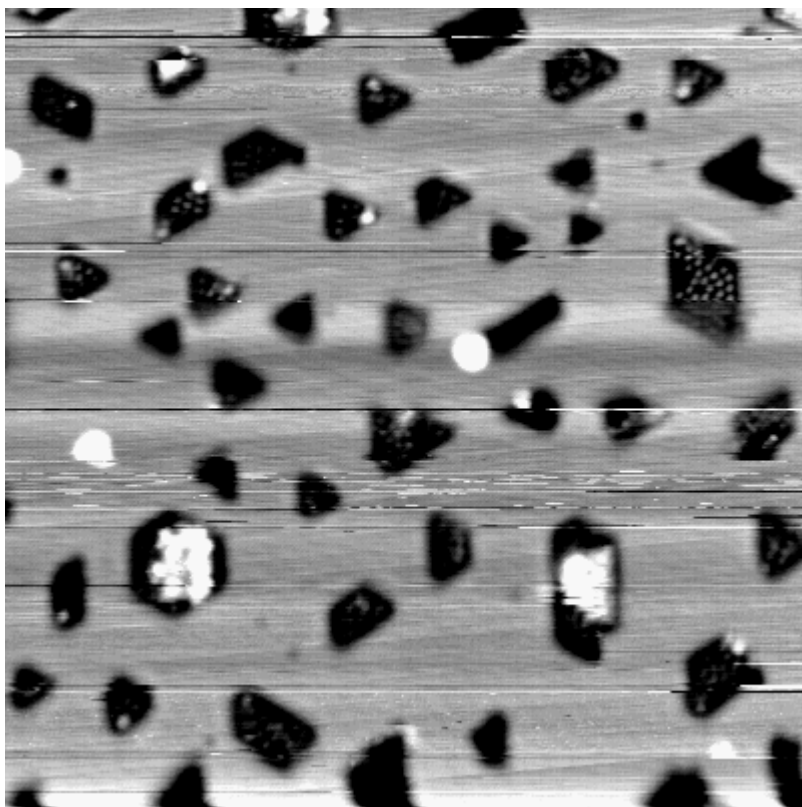
RDE @ 400°C deposit of 4 bilayers Si on 2D RESi. 22 nm \times 8 nm, 1.4 V, 2 nA

H-Terminated RE Silicides

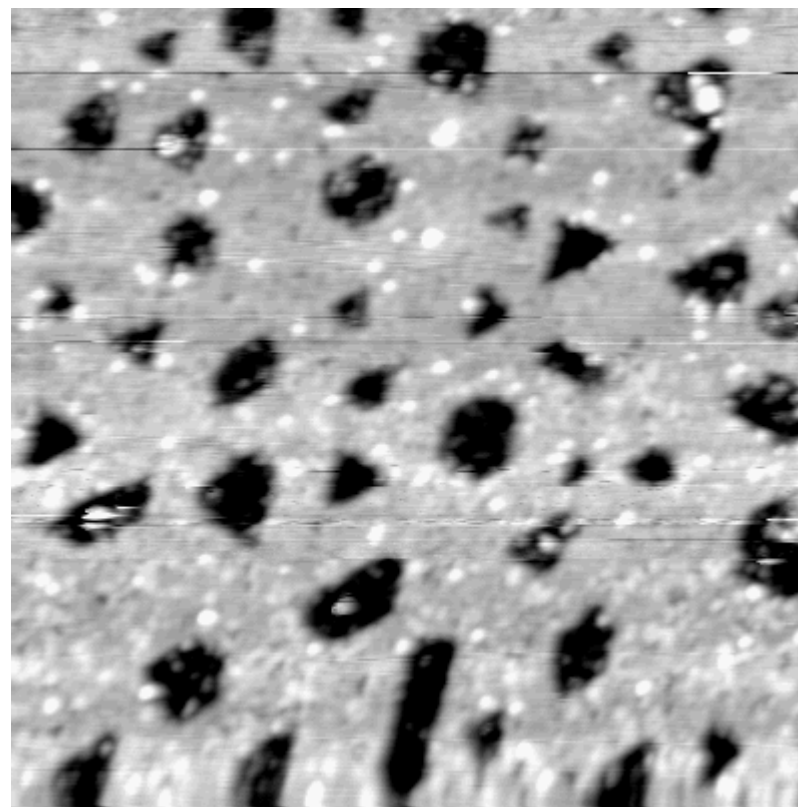
- Although interesting, these surfaces are too heavily islanded to be realistic targets for structural analysis
- Previous studies [1] have established that the top bilayer of a 2D RE silicide is reverse-buckled with respect to the bulk (B-type). This buckling reverts on exposure to atomic hydrogen (A-type)
- There are two hydrogen adsorption sites per unit cell; one associated with the rare earth atom, and one with the uppermost silicon dangling bond
- This adsorption passivates the surface more heavily, and we were interested in the effect that this would have on the overlayer growth

H-Terminated RE Silicides

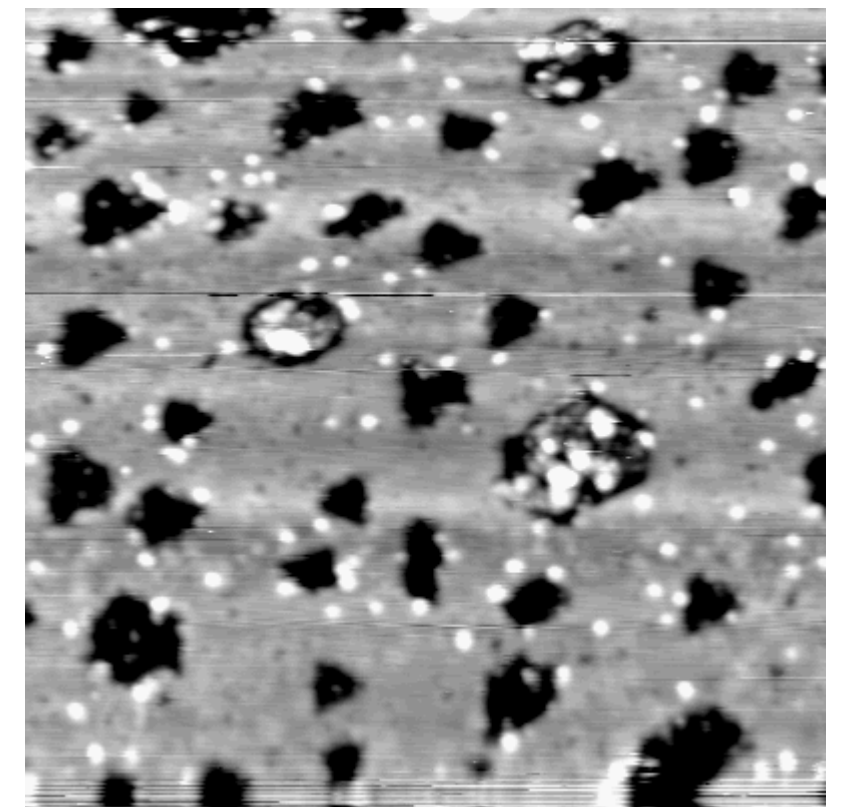
- Comparison of HoSi and H-HoSi surfaces shows that the latter are much rougher, the roughness decreasing with exposure
- Studies from RE-Ge systems [2] indicate ~20% of the upper bilayer may remain B-type
- From the absence of any domain structure, it appears these regions of B-termination are evenly distributed across the surface



SPE @ 400°C deposit of 1 ML Ho.
50 nm × 50 nm, 2 V, 0.2 nA



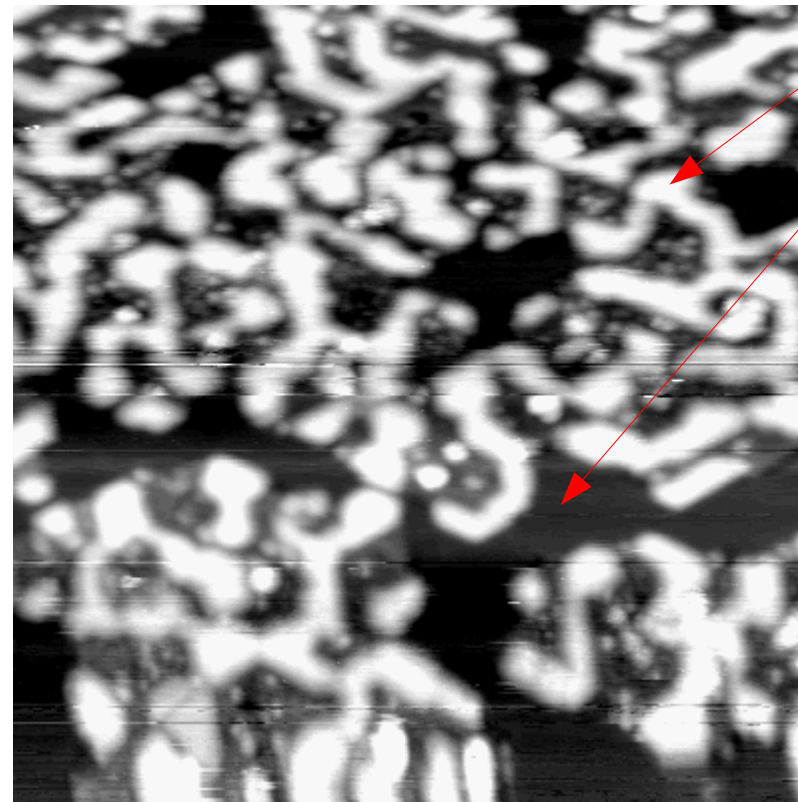
SPE @ 400°C deposit of 1 ML Ho,
10 minute H exposure.
50 nm × 50 nm, 2 V, 0.2 nA



SPE @ 400°C deposit of 1 ML Ho,
20 minute H exposure.
41 nm × 41 nm, 2 V, 2 nA

Si Growth on H-HoSi

- Initial deposition of silicon onto hydrogen terminated HoSi is much flatter than onto plain HoSi
- The networks of silicon islands can be seen nucleating on top of the HoSi substrate, which appears undisturbed
- These islands come to dominate the surface, although holes and clusters of silicon are also evident



Si islands

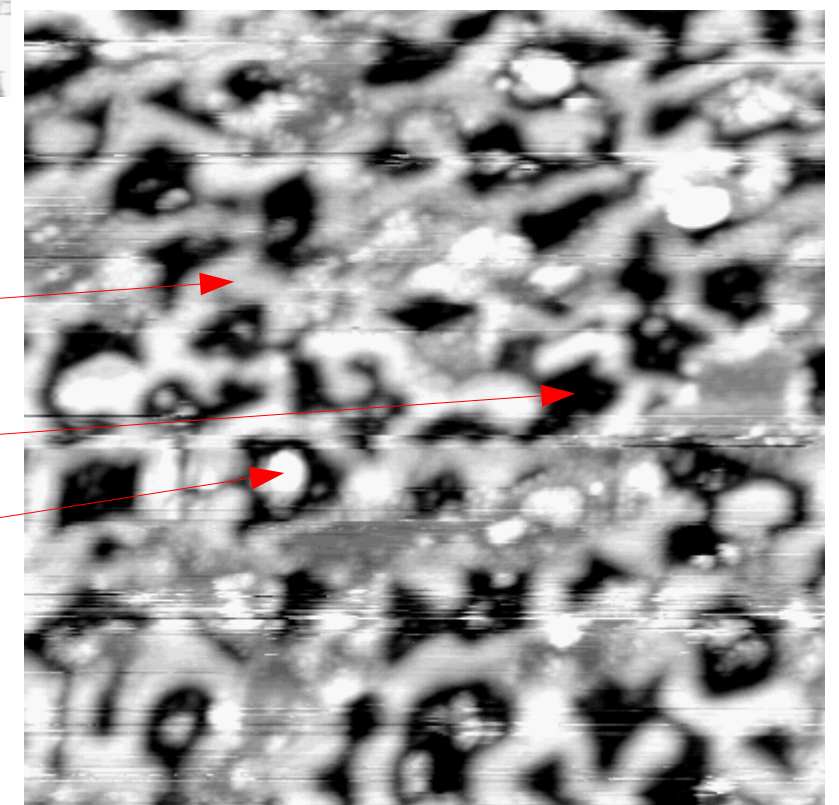
HoSi 1×1 substrate

1 ML Si SPE @ 400°C.
44 nm × 44 nm, 2 V, 2 nA

Si islands

HoSi 1×1 substrate

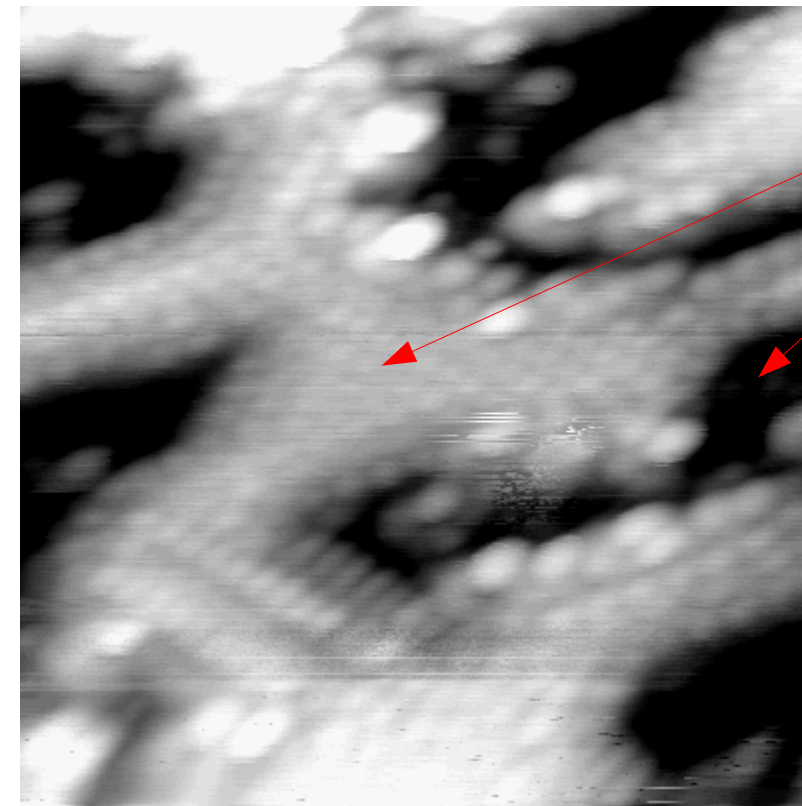
Clusters



1.5 ML Si SPE @ 400°C.
40 nm × 40 nm, 2 V, 2 nA

Silicon Epitaxy

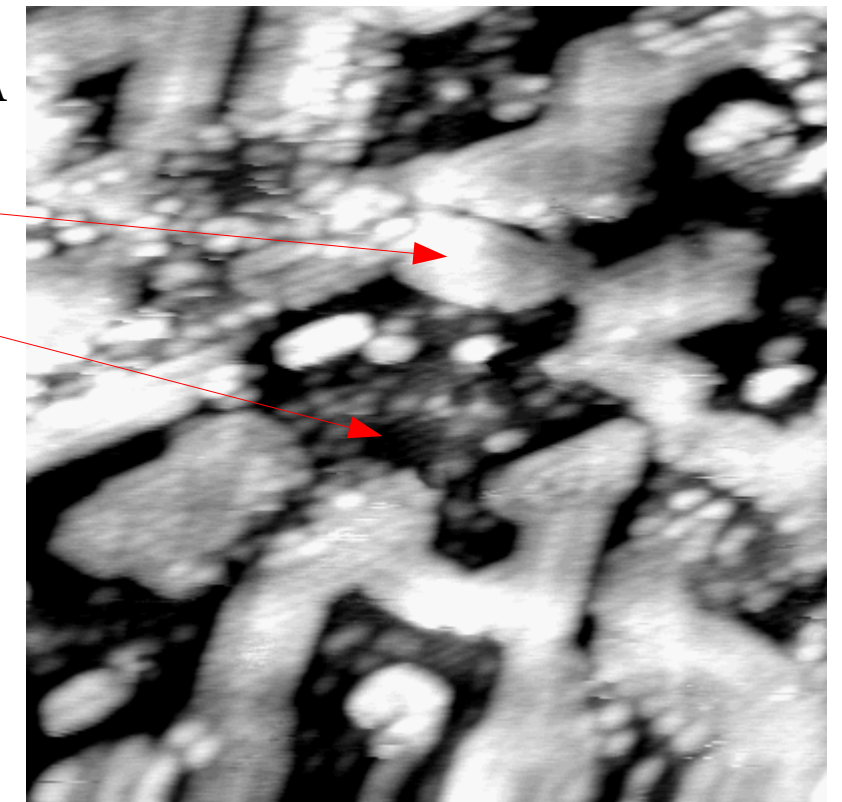
- Negative bias scanning shows that the islands are 1×1 reconstructed
- We propose that this epitaxy proceeds by the silicon substituting for the hydrogen atom terminating the upper dangling bond
- This might leave a hydrogen atom adsorbed to the rare earth atom – but confirming this would require a different technique, e.g. ERDA



1.5 ML Si SPE @ 400°C.
7.8 nm \times 7.8 nm, -2 V, 2 nA

1x1 Si islands

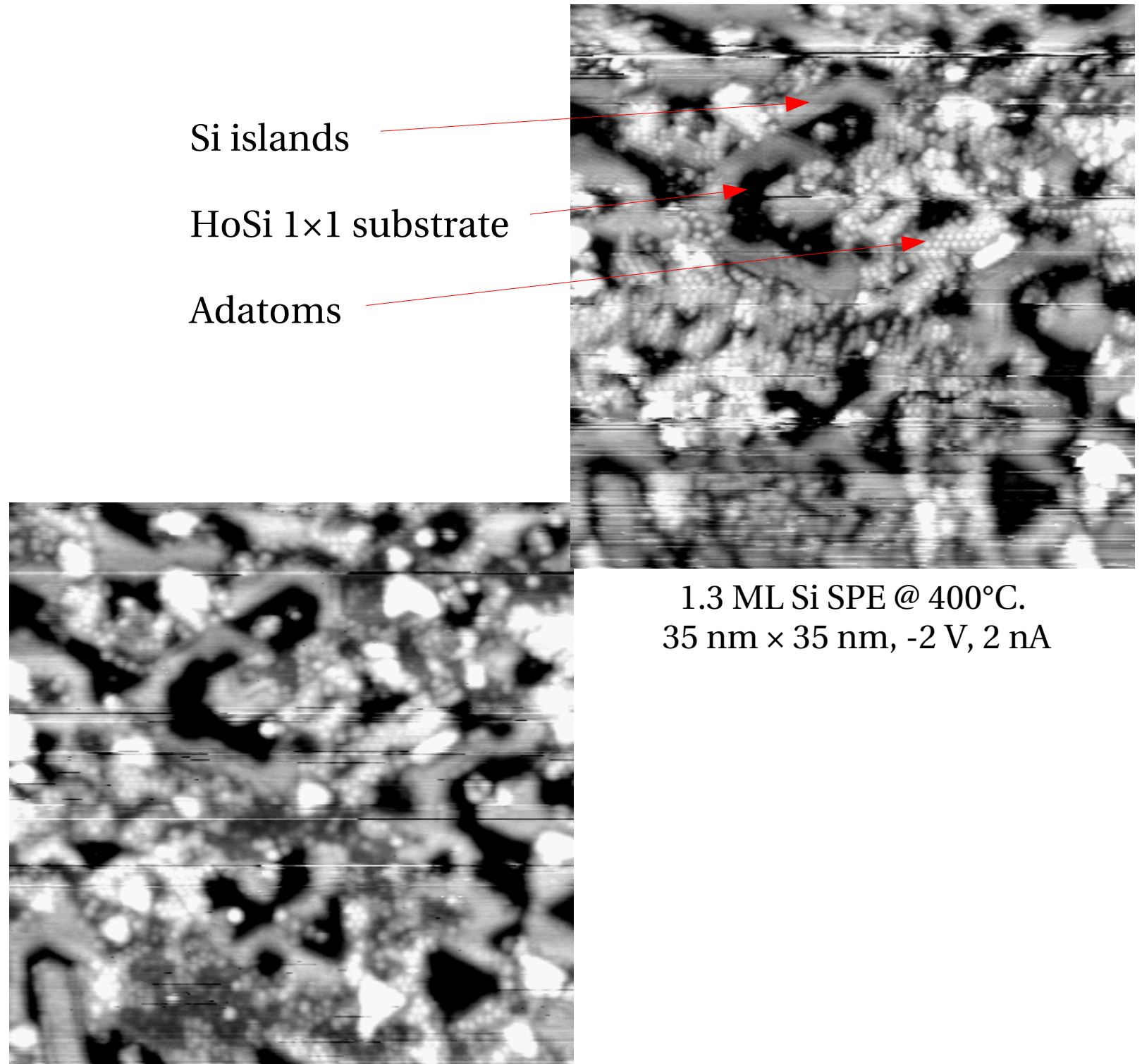
HoSi 1x1 substrate



1.5 ML Si SPE @ 400°C.
17 nm \times 17 nm, -2 V, 2 nA

Si Growth on H-HoSi

- Viewed with negative bias, the clusters become better resolved, and we can see the beginnings of adatoms on the silicon islands
- As coverage increases, we would expect that these regions would reconstruct in the same manner as Si on HoSi



Si islands

HoSi 1×1 substrate

Adatoms

1.3 ML Si SPE @ 400°C.
35 nm × 35 nm, -2 V, 2 nA

1.3 ML Si SPE @ 400°C.
35 nm × 35 nm, 2 V, 2 nA

Conclusions & Further Work

Conclusions

- The nature of the growth of silicon on HoSi and hydrogen-terminated HoSi is quite different
- The improved homogeneity of the surface may make MEIS studies feasible, allowing us to study the structure in detail

Further Work

- MEIS structural studies
- ERDA studies to probe for the presence of hydrogen
- Silane growth on HoSi for comparison

References

- [1] P. Wetzel *et al.*, Europhys. Lett., **38**, 5, p359-364 (1997)
- [2] D. J. Spence *et al.*, Phys. Rev. B, **62**, 8, p5016-5020 (2000)