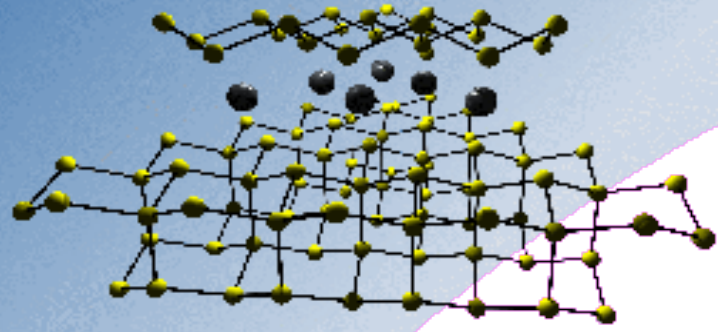


## 2D Rare Earth Silicides



- Novel structure, formed by heavy trivalent rare earths, e.g. dysprosium<sup>[1]</sup>
- Low Schottky barriers ( $\sim 0.3$  eV on *n*-type silicon<sup>[2]</sup>)
- The buckling of the upper Si bilayer is reversed with respect to the bulk direction
- This upper bilayer is almost bulk-terminated, making it an interesting surface for further growth

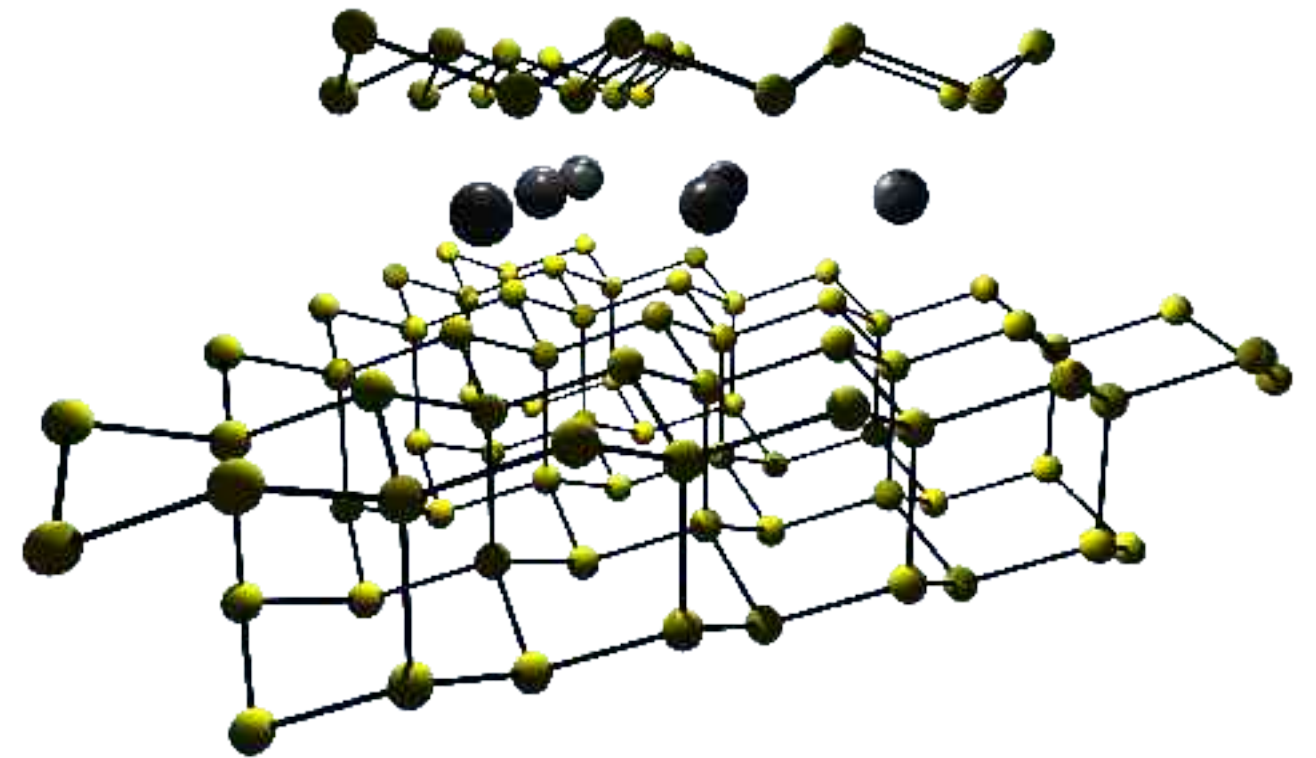
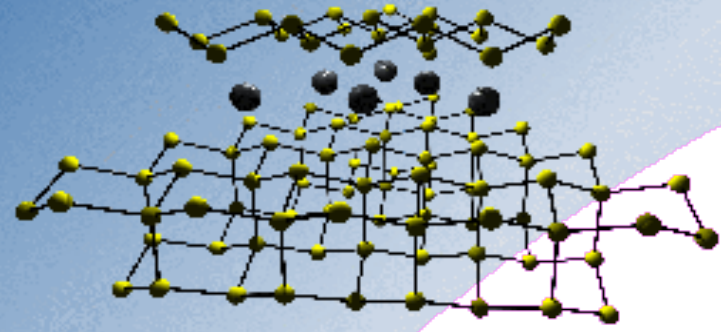


Fig. 1 : Structural model of a 2D rare earth silicide



## Si Growth on 2D Ho Silicide

- Structures grown on top of 2D silicides are particularly accessible to Medium Energy Ion Scattering analysis<sup>[3]</sup>
- $H^+$  ions scattered from the rare earth atoms are blocked by the overlying structure
- Si-RE-Si structures are interesting from an electronic device perspective; accurate structural characterisation is valuable

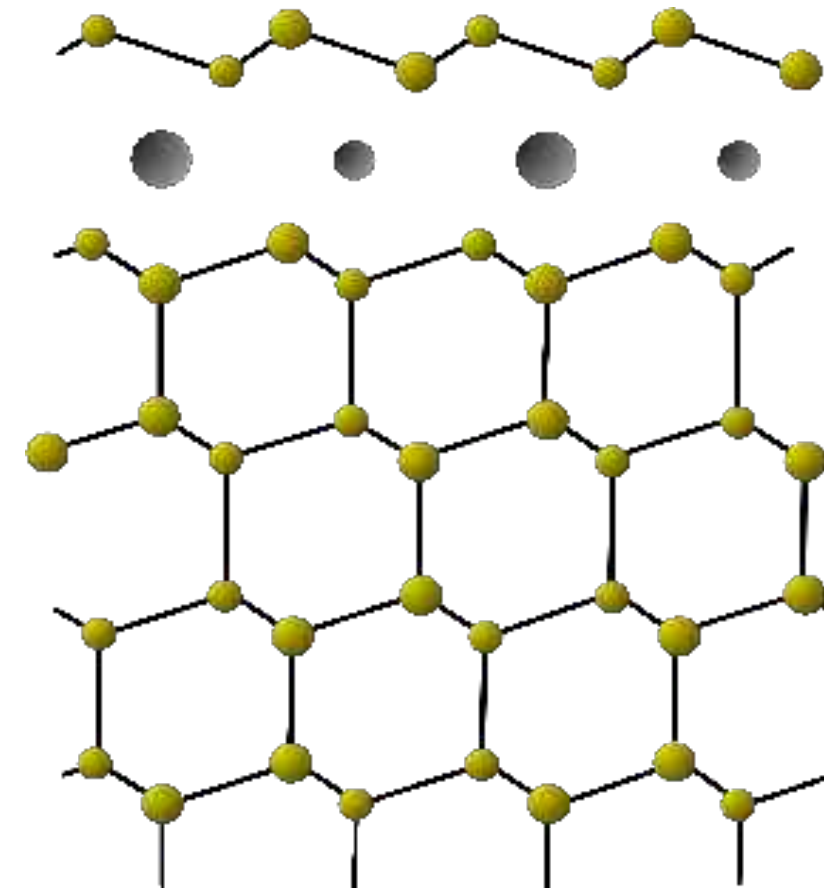
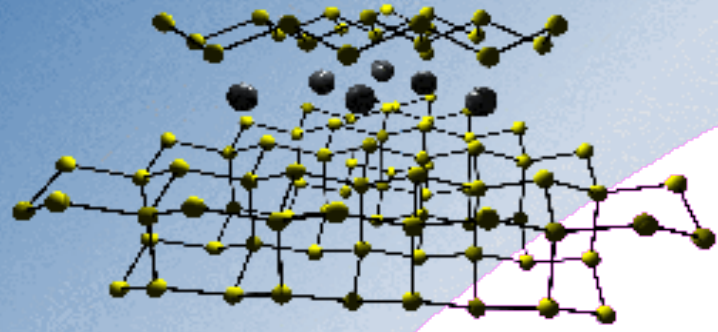


Fig. 2 : 2D rare earth silicide structure



## 0.5 Bilayer Deposition

- 0.5 bilayers of Si deposited at RT onto a 2D Ho silicide, post-annealed at 300 °C
- At this stage of growth, the silicon has nucleated into islands around the defects in the silicide
- We can see the Ho-induced  $(2\sqrt{3}\times 2\sqrt{3})R30^\circ$  reconstruction on some of the islands, implying the presence of free Ho on the surface

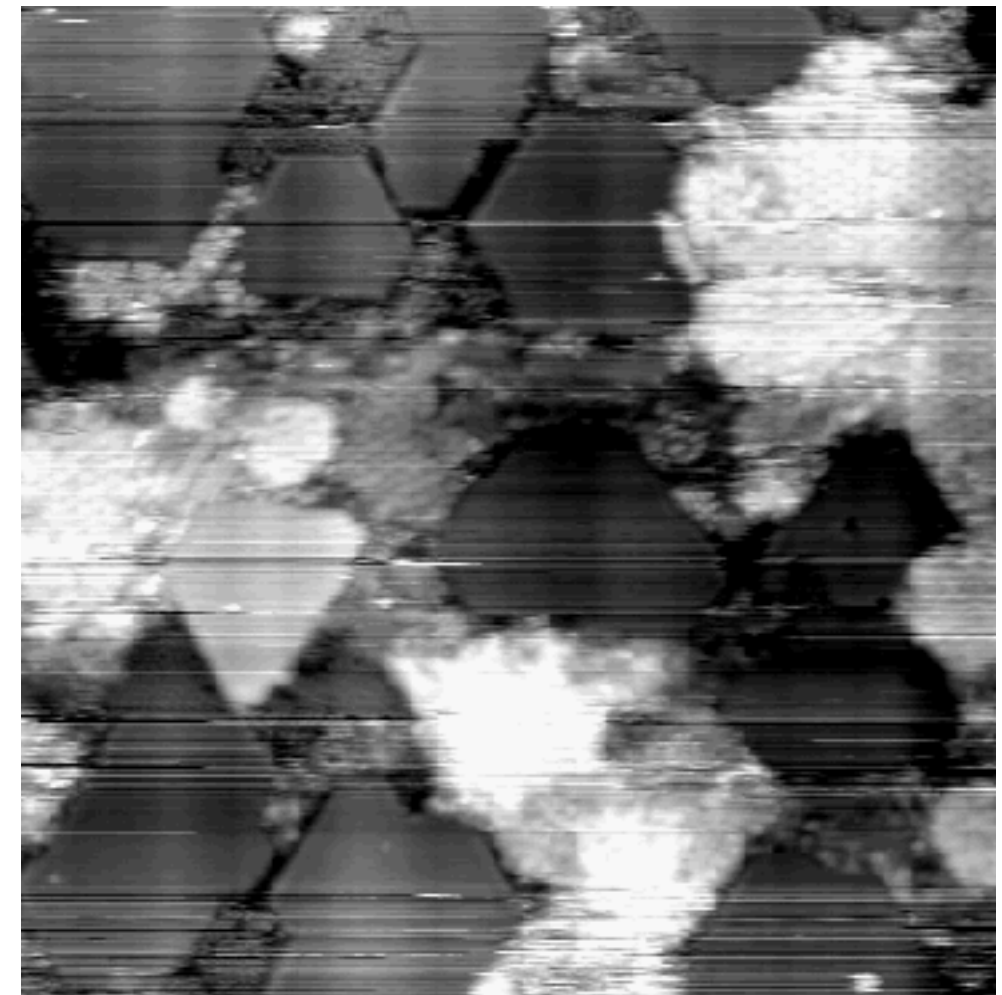
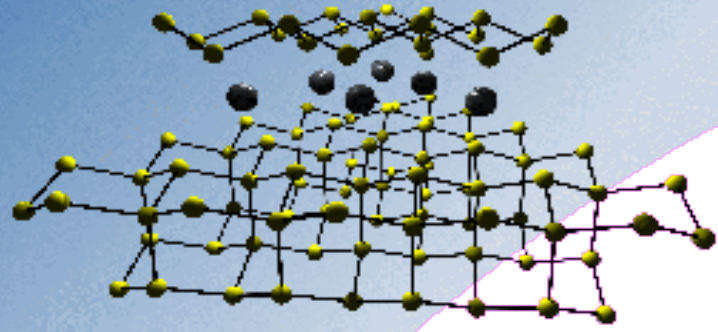


Fig. 3 : 69 nm × 69 nm, 2 V, 2 nA

## 1 Bilayer Deposition I



- 1 bilayer of Si deposited at RT onto a 2D Ho silicide, post-annealed at 450 °C
- Fig. 4 shows a 1×1 hole in a 1×1 island on this surface
- The height difference between the two is very small, and there is a difference in registry

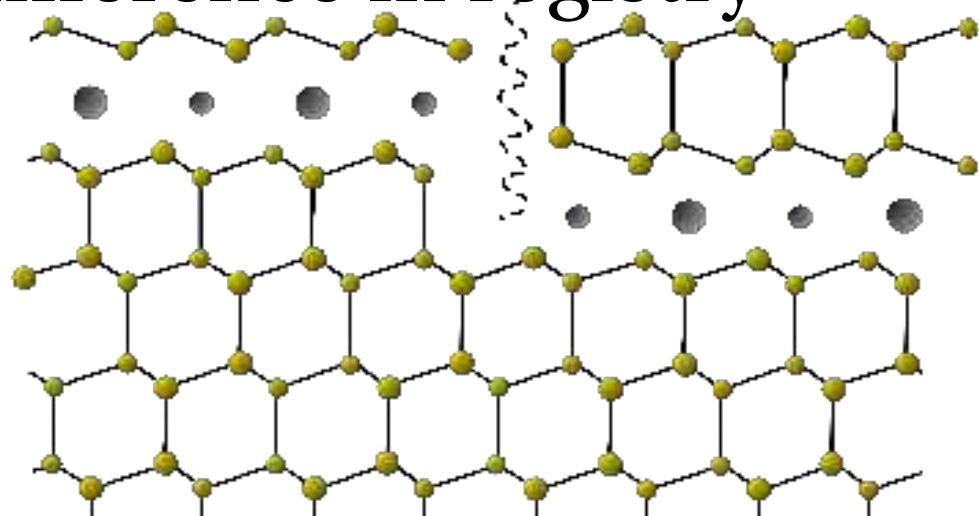


Fig. 5 : Proposed model for this surface

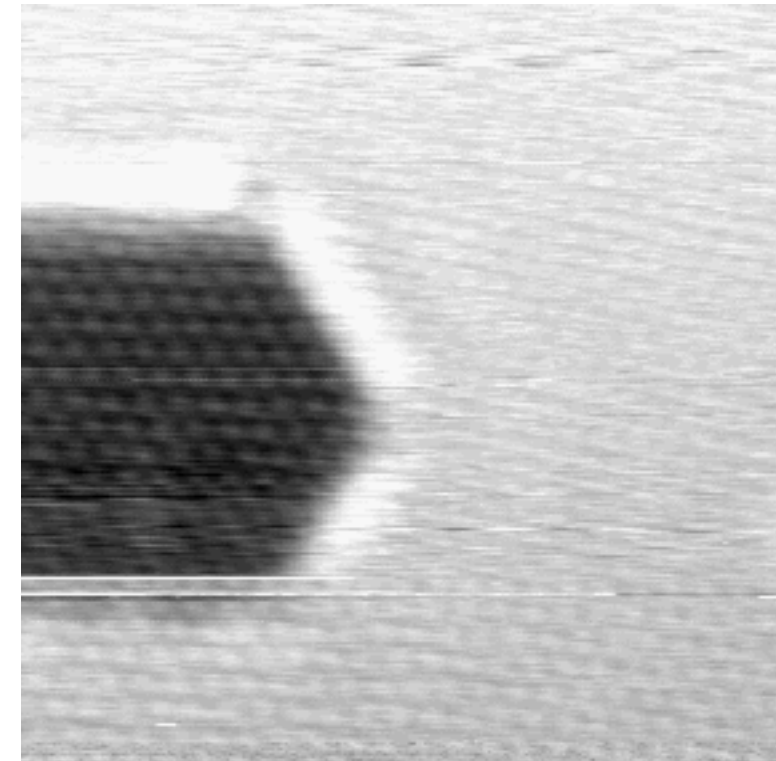
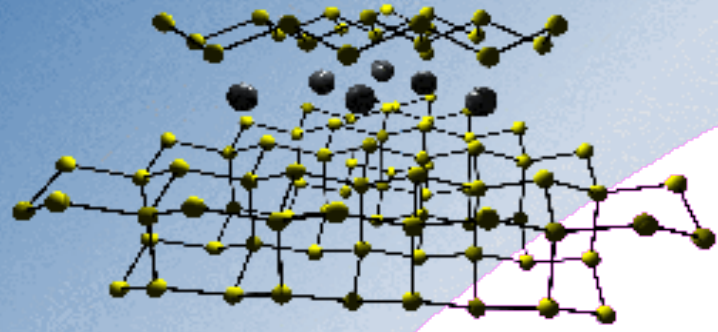


Fig. 4 : 7.5 nm × 7.3 nm, 1 V, 2 nA

- In our proposed model, Fig. 5, the hole is a region where the RE atoms are nearer the surface, compensating the Si dangling bonds



## 1 Bilayer Deposition II

- This image, taken from the same surface as in Fig. 4, shows the region adjacent to the hole
- The image achieves resolution of the lower silicon atoms in the bilayer, allowing us to determine the orientation of the bilayer

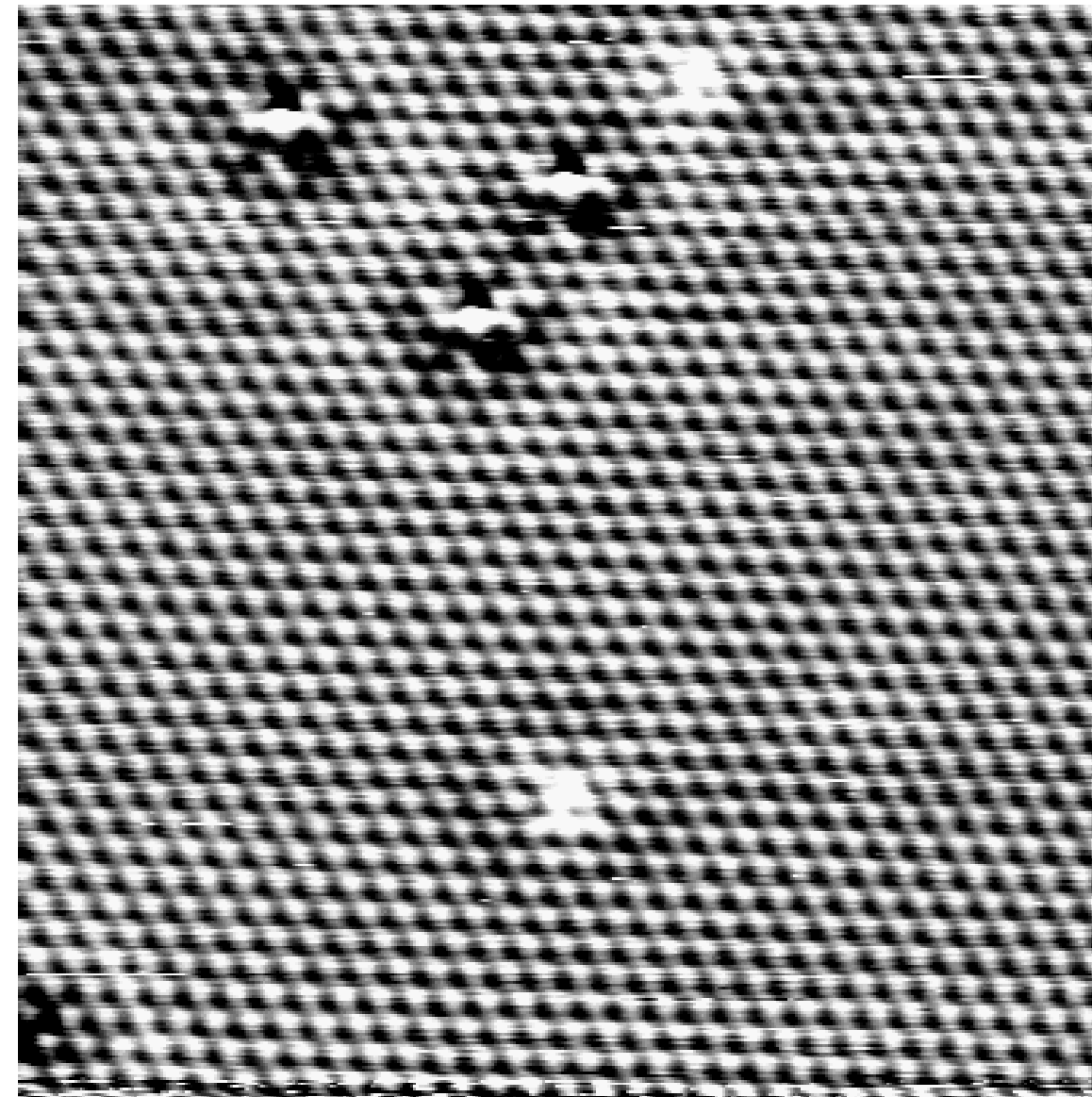
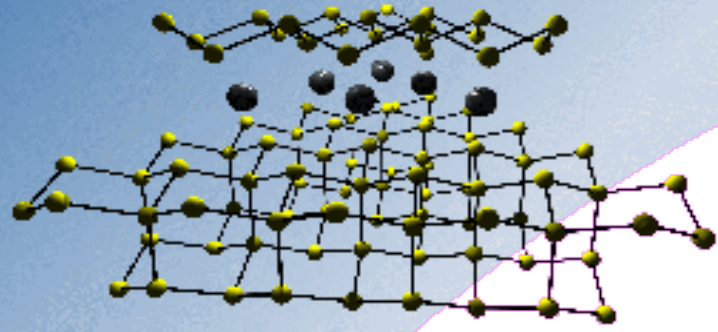


Fig. 6 10 nm × 10 nm, 1 V, 6 nA



## 2 Bilayer Deposition

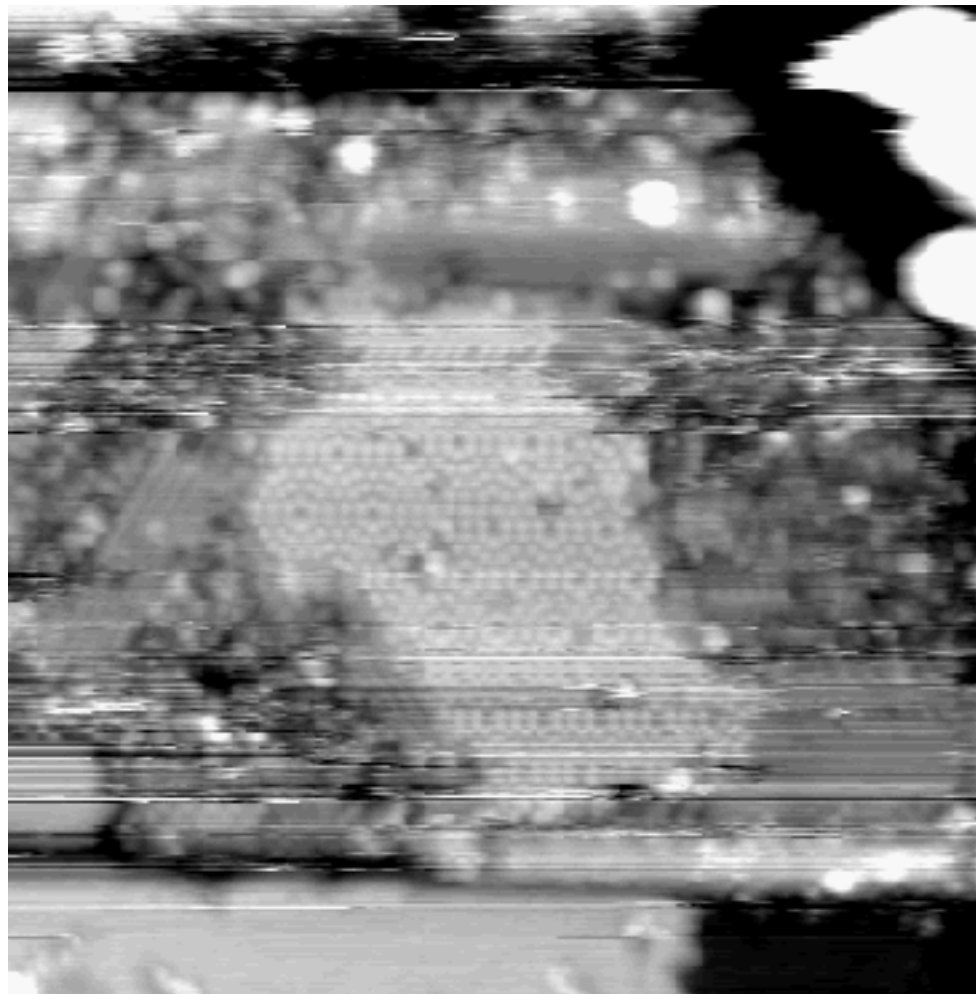
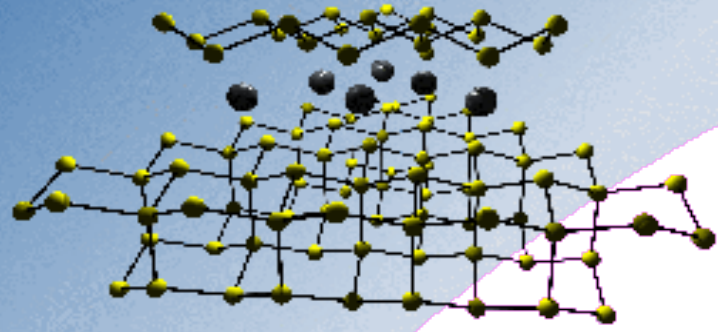


Fig. 7 40 nm × 40 nm, 1.5 V, 2 nA

- Sample was 2 BL of Si deposited on a 2D Ho silicide at RT, followed by a 30min anneal at 450 °C
- The central island is reconstructed in a mixture of 7×7 and 9×9 structures, surrounded by a poorly ordered region.



## 4 Bilayer Deposition

- 4 BL deposit of Si on a 2D Ho silicide, held at 450 °C, plus 30 min subsequent anneal
- Areas of both 7×7 and 2×1 reconstructions are visible
- If this is the 2×1 silicon reconstruction, it would illustrate the very small energy difference between the two reconstructions
- It is possible that the 2×1 reconstruction is holmium-induced

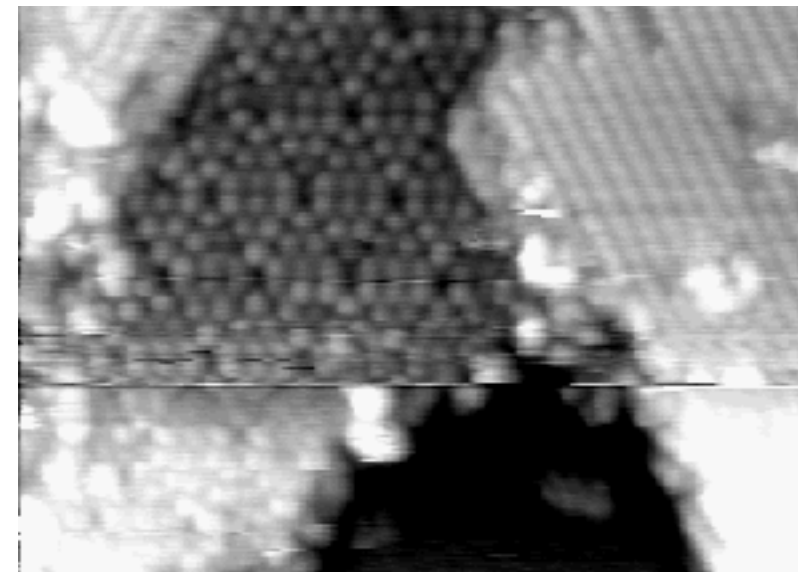


Fig. 8 a)  
20 nm × 14 nm,  
-3 V, 2 nA

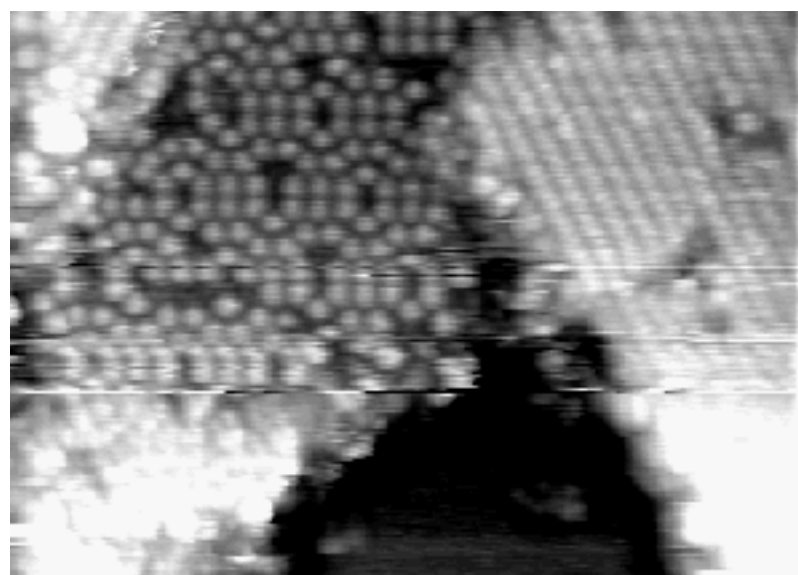
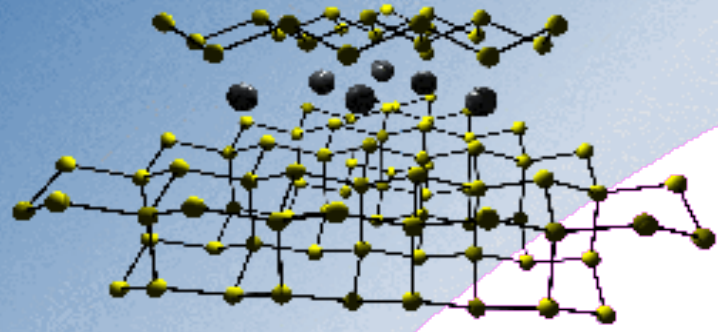


Fig. 8 b)  
20 nm × 14 nm,  
1.4 V, 2 nA



## Conclusion and Future Work

- We have performed STM studies of Si overlayers on 2D Ho silicide
- We have observed epitaxial growth of these overlayers, and proposed a model
- The formation of the  $7\times 7$  and  $2\times 1$  reconstructions has been seen
- There is still some way to go in achieving good quality overlayer films, suitable for MEIS analysis
- We have yet to explore the possibility of Ho-Si codeposition to improve the quality of the initial 2D silicide

### References

- [1] D.J. Spence *et al.*, Surface Science 512 (2002) pp. 61-66
- [2] K.N. Tu *et al.*, Appl. Phys. Lett. **38** (8) 15<sup>th</sup> April 1981, pp. 626-628
- [3] J.F. Van der Veen, Surface Science Reports **5** 5-6 (1985), p 199

### Acknowledgements

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