

2D Rare Earth Silicides

- Novel structure, formed by heavy trivalent rare earths, e.g. dysprosium^[1]
- Low Schottky barriers (~ 0.3 eV on *n*-type silicon^[2])
- Possible electronic applications
- Other notable phases exist at other coverages

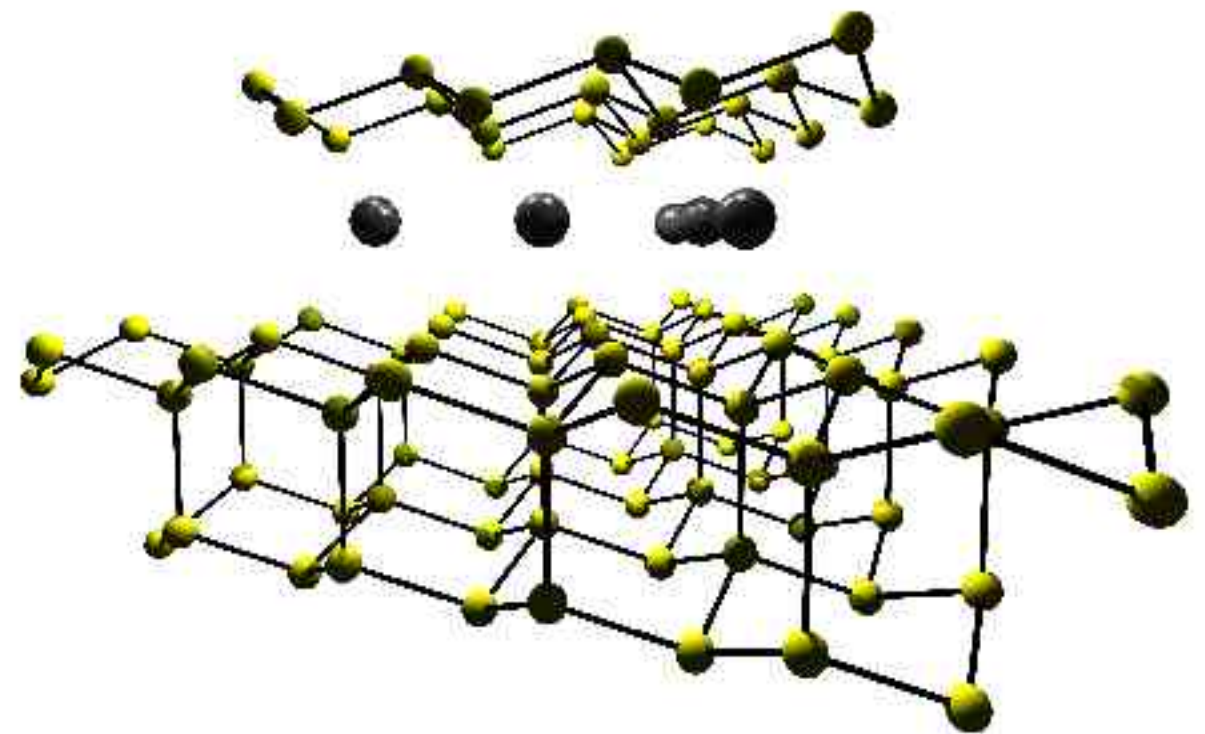
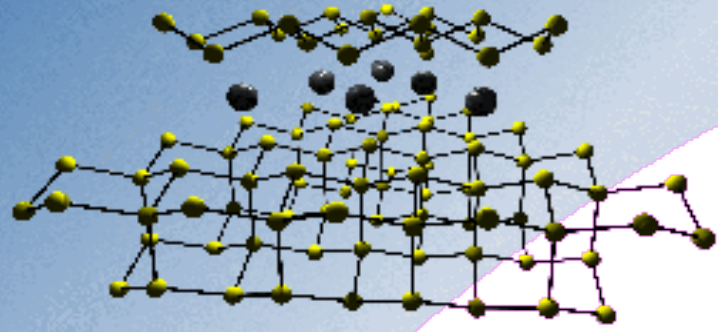


Fig. 1 : Structural model of a 2D rare earth silicide



Neodymium Silicides?

- Neodymium is a largely divalent, light rare earth
- Its behaviour on Si(111) has not been well studied, although there has been some work on Si(001)^[3]
- MEIS and LEED work in the York group has shown a variety of reconstructions
- 1×1 , 2×2 and $(\sqrt{3}\times\sqrt{3})R30^\circ$ reconstructions have all been observed

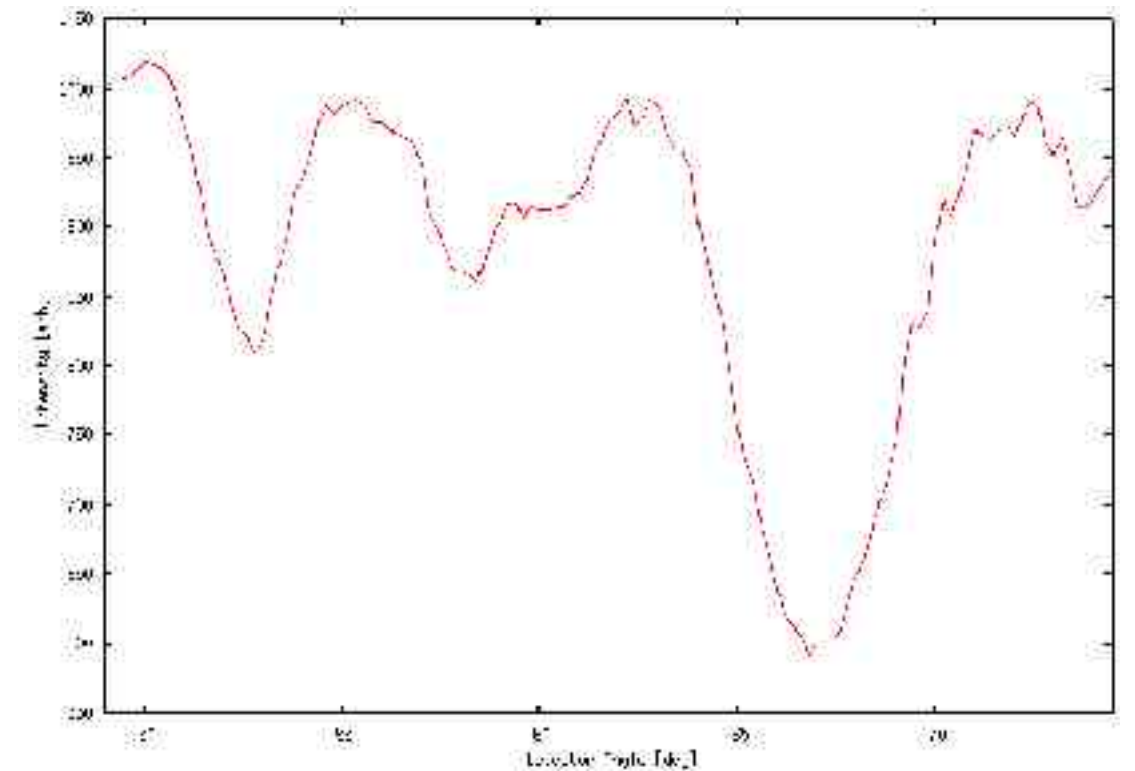
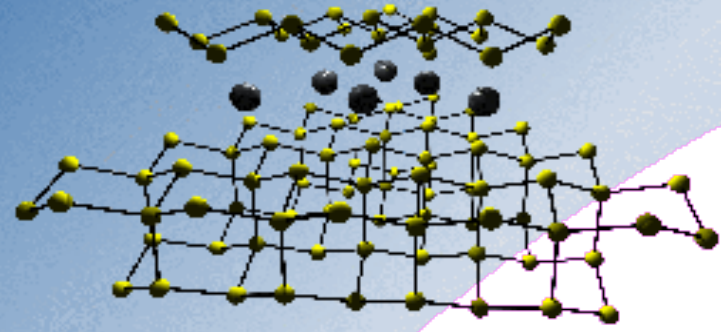


Fig. 2 : MEIS data and blocking curve of 1×1 NdSi^[4]



Sub-monolayer Coverages I

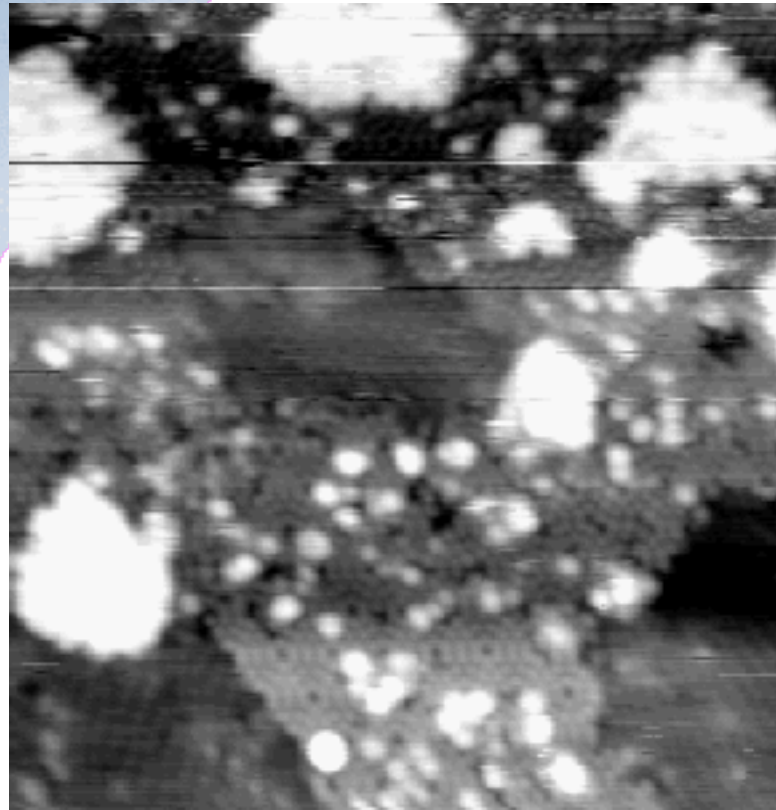


Fig. 3 a)
34 nm×34 nm,
2 V, 2 nA

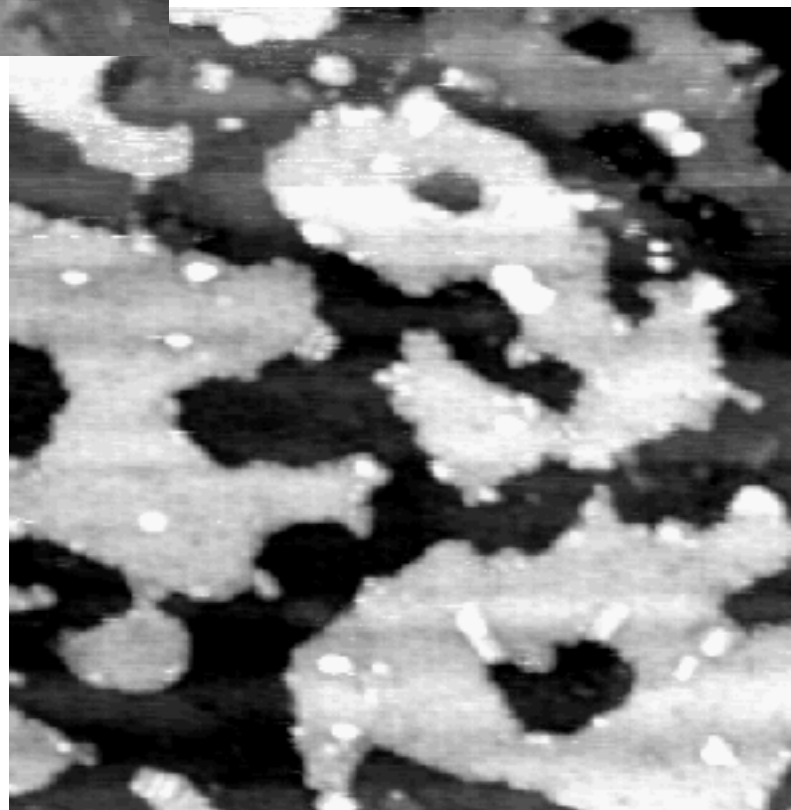


Fig. 3 b)
50 nm×50 nm,
2 V, 2 nA

- RT deposit, followed by ~ 500 °C anneal
 - a) 0.2 ML – 2×2 holes and islands on 7×7 structure.
 - b) 0.5 ML – islands coalesce
- Nd-induced reconstructions are poorly ordered at these anneal temperatures
- Behaviour is comparable with holmium on Si(111), but forms a 2×2 as opposed to Ho' s $(2\sqrt{3}\times 2\sqrt{3})R30^\circ$

Sub-monolayer Coverages II

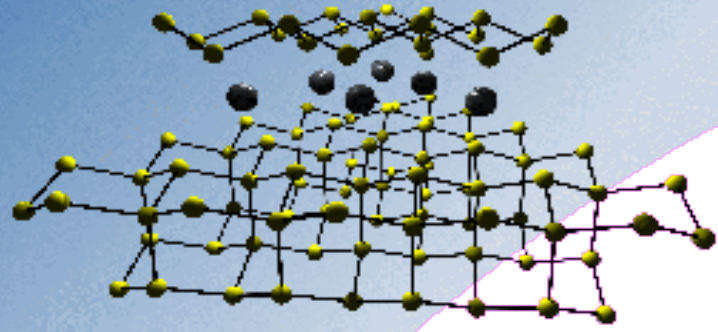
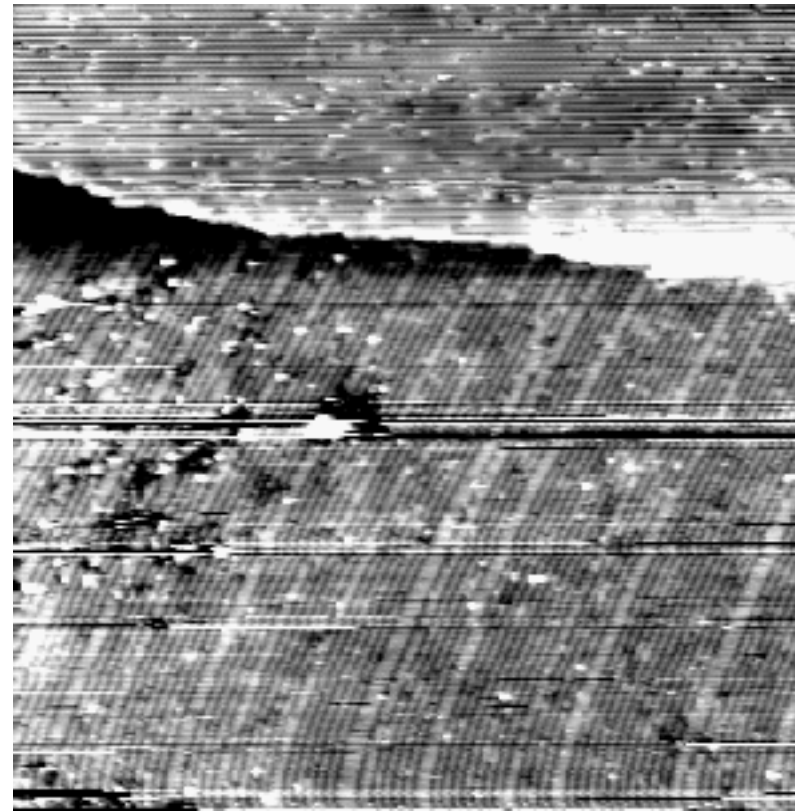


Fig. 4 a)
125 nm × 125 nm,
2 V, 2 nA



- Annealing previous 0.2 ML sample to 1200 °C gives a strong 5×1 LEED pattern
- The surface is covered with “nanowire” type structures
- These are organised in three domains, the orientation of which alters at step-edges

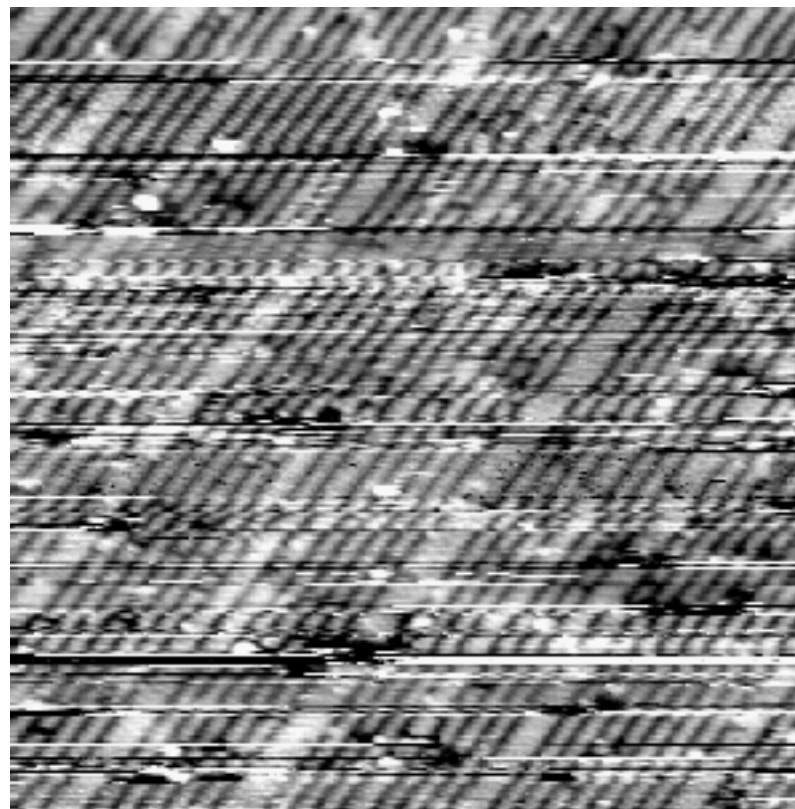


Fig. 4 b)
53 nm × 53 nm,
2 V, 2 nA

Sub-monolayer Coverages III

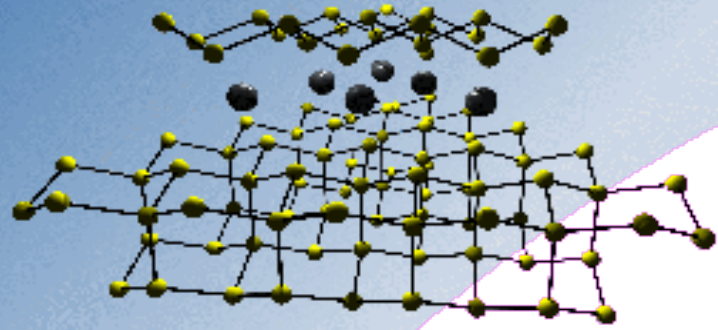


Fig. 5 a)
40 nm×40 nm,
-1.7 V
Filled states

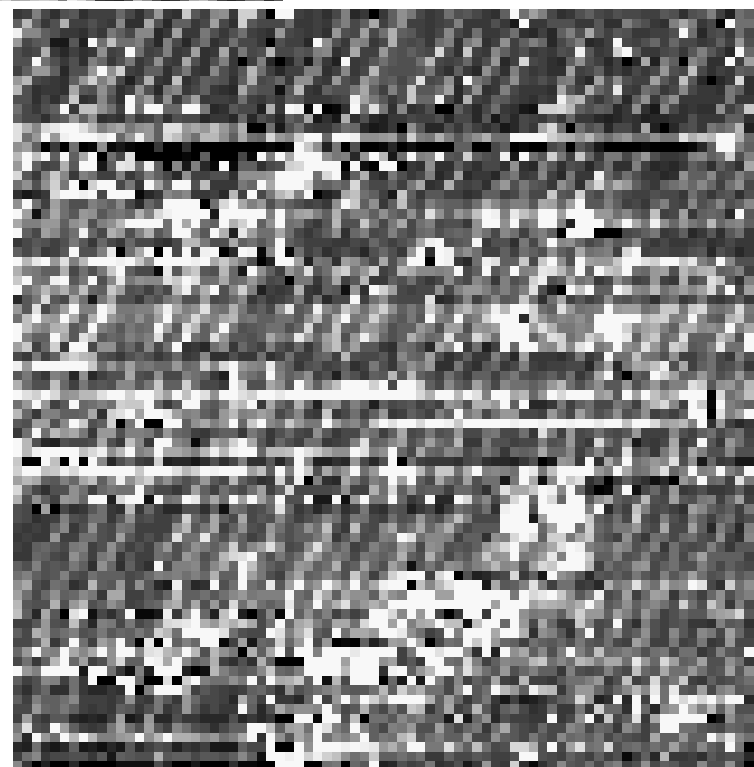
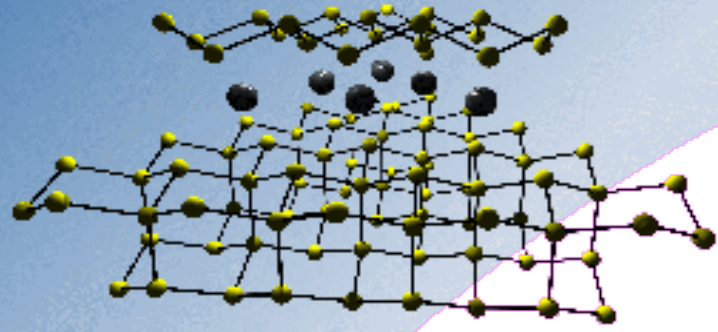


Fig. 5 b)
40 nm×40 nm,
+3 V
Empty states

- Figs. 5 a) and b) are CITS images of the sample shown in Fig. 4
- The “nanowires” are clearly visible as regions of filled states in CITS imaging
- The areas between the wires are characterised by empty states
- Previous MEIS experiments confirm the 5×1 structure's coverage is 0.2 ML, with the Nd on the surface



Sub-monolayer Coverages IV

- Previous 0.5 ML sample after anneal to 1200°C
- 2×2 “substrate”, under wire-like overlayer
- LEED pattern shows 4×2 spots, but only in two domains
- It is unknown what structure these spots are associated with

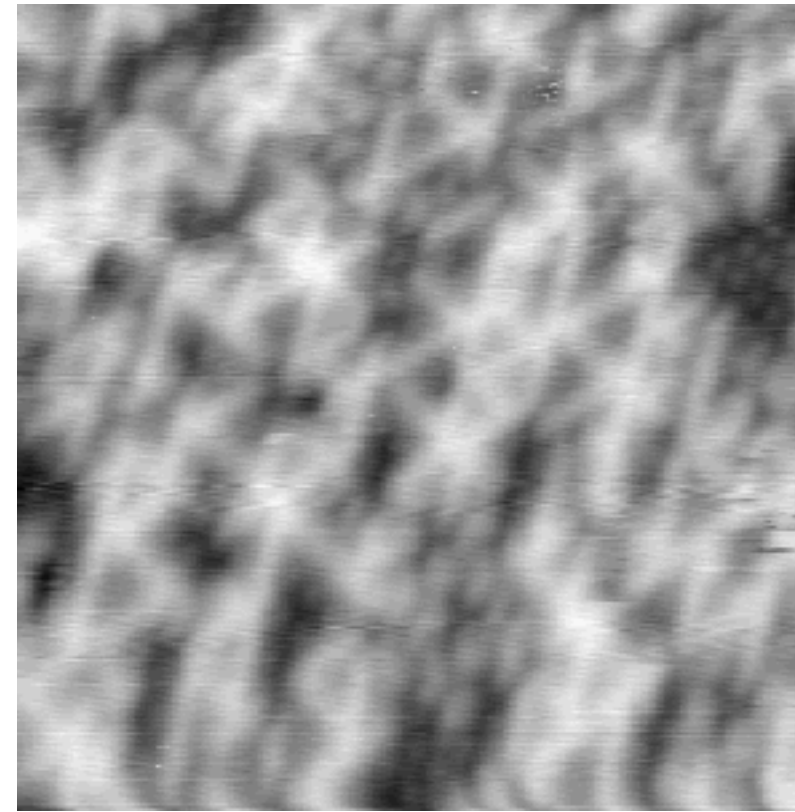


Fig. 6 a)
16 nm×16 nm,
2 V, 2 nA

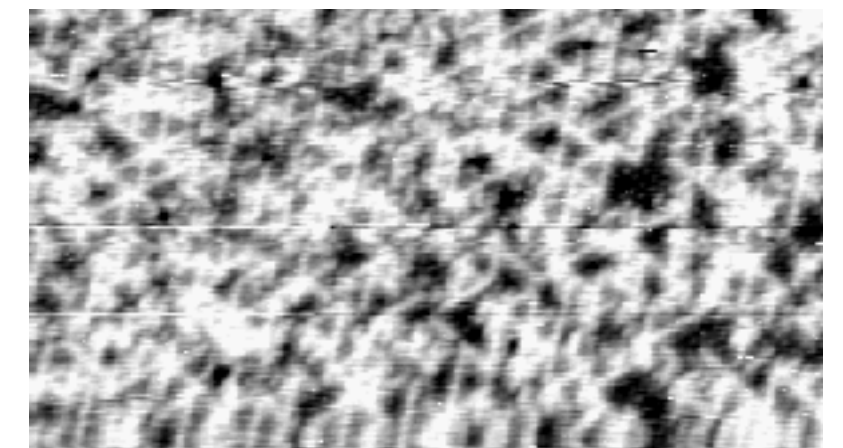
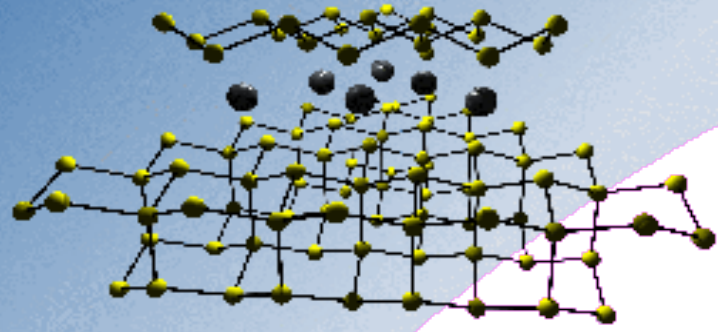


Fig. 6 b)
40 nm×23 nm,
2 V, 2 nA



>1ML Coverages

- At coverages greater than one monolayer, followed by a 600 °C anneal, a poor 1×1 LEED pattern is observed
- The surface is composed of many small islands, with a great deal of height variation
- We anticipate that these islands are 1×1 reconstructed, the islanding giving rise to the poor LEED

Fig. 7 a)
205 nm \times 205 nm,
2 V, 2 nA

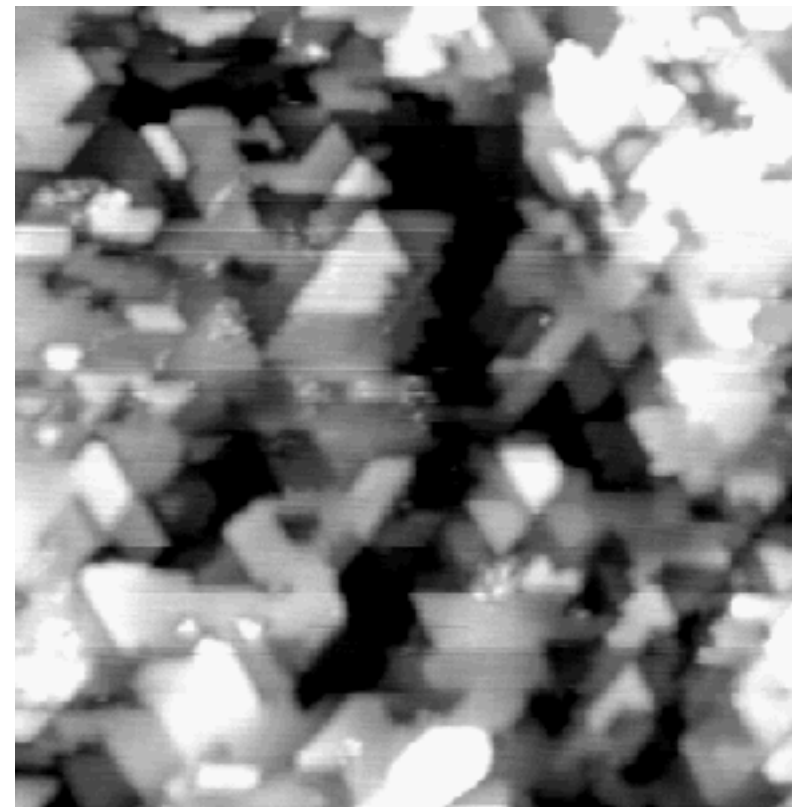
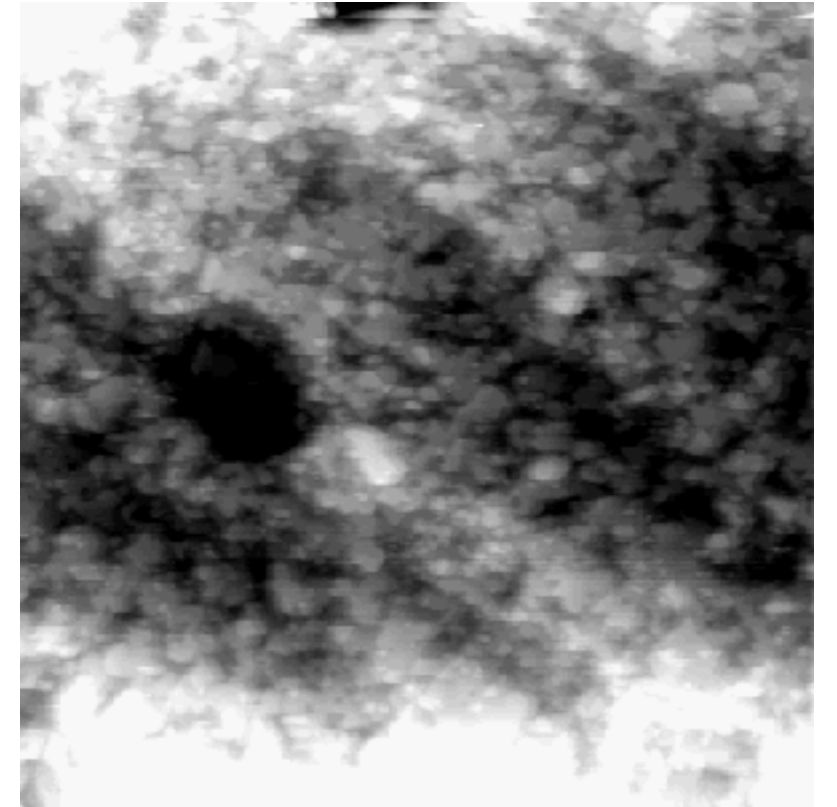
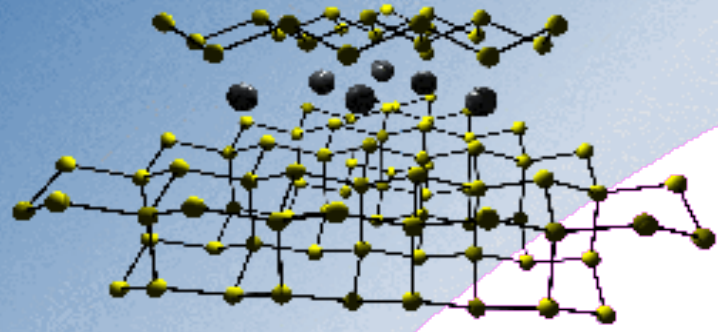


Fig. 7 b)
60 nm \times 60 nm,
2 V, 2 nA



Conclusions and Future Work

- STM has been performed on Nd silicides, on Si(111), in conjunction with MEIS studies^[4]
- Neodymium forms a number of well-ordered structures on Si(111)
- These include arrays of nanowires and a 2×2 reconstruction
- Future Work
 - We intend to pursue the sharp 1×1 which has been seen at 1 ML coverages
 - Are the “nanowires” wires in the sense that they are truly conductive?
 - Further characterisation work of the 2×2 surface, possibly using LEED to determine precise structure

References

- [1] D. J. Spence *et al.*, Surf. Sci. **512** (2002) pp. 61-66
- [2] K. N. Tu *et al.*, Appl. Phys. Lett. **38** (8) (1981) pp. 626-628
- [3] M. V. Katkov *et al.*, Surf. Sci. **524** (2003) pp. 129-136
- [4] T. J. Wood *et al.*, to be published

Acknowledgements

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