Building Electronic Devices from Clusters

S. A. Brown[1,2,3], J. G. Partridge[1,3], R. Reichel[1,3], A. Ayesh[1,3], P. Convers[1,3], A. Sattar[1,3], J. van Lith[2], A. Lassesson[2], F. Natali[1,3], E. Boyd[1,3], K. C. Tee[1,2], D. M. A. Mackenzie[1,3], A. Awasthi[1,4], S. C. Hendy[1,4,5], P. Zoontjens[1,5].

[1] *MacDiarmid Institute of Advanced Materials and Nanotechnology*

[2] *Nano Cluster Devices Ltd*, *Christchurch, New Zealand,*

[3] *Department of Physics and Astronomy, University of Canterbury, Christchurch, New Zealand,*

[4] *Industrial Research Ltd, PO Box 31-310, Lower Hutt, New Zealand,*

[5] *Victoria University of Wellington, PO Box 600, Wellington, New Zealand*

simon.brown@canterbury.ac.nz

Regular attendees at ISSPIC conferences are well aware of the enormous variety of novel physical and chemical phenomena observed in clusters. Over the years, fundamental studies of gas phase properties have evolved towards more applied studies of clusters on surfaces, and the possibility of "new" materials formed from clusters. A logical continuation of this evolution is the use of clusters as building blocks for electronic devices.

We believe that the ready availability of clusters with sizes ranging from a few atoms up to tens of nanometres makes them ideal building blocks for electronic devices. This size range spans the gap between current integrated circuits (~50nm) and the molecular scale (<1nm), which is presumably the ultimate future of electronics.

We have developed self-assembly / directed-assembly strategies [1, 2, 3, 4] which provide a potentially manufacturable route to fabrication of cluster-based electronic devices. We have focussed on the formation of contacted cluster chains / nanowires because devices containing such nanowires have a wide range of applications (from chemical sensors to transistors). In this paper we will review our work on nanowire formation using templates [1, 2], stencils [3] and percolation methods [4], as well as our understanding of the basic physical assembly processes (enhanced by extensive Molecular Dynamics simulations [5]). We will also discuss prototype hydrogen sensors based on Pd clusters [6], H_2 and NH_3 gas sensors based on oxidised Sn clusters [7], the use of Cu clusters for interconnect applications [8], and progress toward the fabrication of cluster-assembled transistors [9].

[1] J. G. Partridge et al, *Nanotechnology* **15**, 1382 (2004).

[2] R. Reichel et al, *Applied Physics Letters* **89**, 213105 (2006).

[3] J. G. Partridge et al, *Microelectronic Engineering* **83**, 1460 (2006).

[4] J. Schmelzer et al, *Phys. Rev. Lett.* **88**, 226802 (2002).

[5] A. Awasthi et al, *Phys. Rev. Lett*. **97**, 186103 (2006).

[6] J. van Lith et al, *Applied Physics Letters* **91**, 181910 (2007).

[7] A. Lassesson et al, *Nanotechnology* **19**, 015502 (2008).

[8] K. C. Tee et al *IEEE Trans. Nano.* **6**, 556 (2007).

[9] E. Boyd et al, to be published.