channel in which electrons flow by means of diffusive transport from source to drain, indicating that a switch has been flipped. Having performed this implantation step in a batch of devices, Shinada *et al.*[1] showed that the distribution of voltages at which transistor currents begin to flow is much narrower than in a batch in which dopant atoms are distributed randomly (Fig. 1b). Tight control of both the number of ions and their location was critical to this achievement.

These results are important because they show a path to the design of Coulomb potential landscapes in a high-yield process that does not rely on fortuitous events. Single-ion implantation is also a technique with wide applicability, allowing the doping of many materials with many different ion species across the periodic table. It is indeed remarkable that the effect of ordered doping manifests itself already at room temperature, and in devices that are rather large by today's standards, with channel areas measuring 0.3 µm by 3.2 µm (in comparison with the 0.1 µm scale of present commercial transistors).

The ability to place exactly one atom at a time into a selected location also brings us closer to testing radically new device concepts. The grand prize might be a large-scale quantum computer. Now that we have succeeded in scaling essentially classical devices down to just a few tens of nanometres in size, we can take quantum mechanics seriously and can seek to use it to perform computational feats that are beyond the reach of classical transistors even when scaled to their ultimate limits. Several promising proposals for scalable quantum computing are based on the coherent manipulation of states in single dopant atoms placed in electronic materials, such as silicon[6] or diamond[7]. With some further optimization of the efficiency of detecting single ions[8] combined with enhanced accuracy in placing ions[9] and optimized control in overall processing statistics[10], single-ion implantation will soon lead to the systematic testing of building blocks for quantum computers with single-atom-based quantum bits, and will enable exciting studies of single-atom transport effects.

REFERENCES

1. Shinada, T., Okamoto, S., Kobayashi, T. & Ohdomari, I. *Nature* **437,** 1128–1131 (2005).
2. Chang, L. *et al. Proc. IEEE* **91,** 1860–1873 (2003).
3. Park, J. *et al. Nature* **417,** 722–725 (2002).
4. Shinada, T., Ishikawa, A., Fujita, M., Yamashita, K. & Ohdomari, I. *Jpn J. Appl. Phys.* **38,** 3419–3421 (1999).
5. Shinada, T. *et al. Jpn J. Appl. Phys.* **41,** L287–L290 (2002).
6. Kane, B. E. *Nature* **393,** 133–137 (1998).
7. Jelezko, F. *et al. Phys. Rev. Lett.* **93,** 130501 (2004).
8. Jamieson, D. N. *et al. Appl. Phys. Lett.* **86,** 202101–202103 (2005).
9. Persaud, A. *et al. Nano Lett.* **6,** 1087–1091 (2005).
10. Schenkel, T. *et al. J. Appl. Phys.* **94,** 7017–7024 (2003).

MATERIAL WITNESS

Nobel intentions

By the time this article goes to press, the lives of a handful of scientists will have been changed forever by a call from Stockholm. But there is of course no Nobel prize for materials science, just as there is none for earth sciences, mathematics, engineering — or indeed, if we are literal about it, for biology (which is one reason why the life sciences have so heavily colonized the chemistry prize).

Some of these disciplines have their own equivalents of the Nobels. The $500,000 Crafoord prize was explicitly created in 1980 to fill the gaps in the Swedish awards, although it still makes no space for research on materials. The US Materials Research Society's Von Hippel award is its highest accolade, but it is hardly a headline-grabber.

This doesn't mean that all materials scientists are doomed to labour in obscurity, of course. The field is easily broad enough now to have claimed a brace of Nobels, not least in the gala year of 2000 when both the physics and the chemistry prizes were awarded in areas that would not look out of place in the *Materials Research Society Bulletin*, *Advanced Materials* or, needless to say, *Nature Materials*.

In chemistry, Alan Heeger, Alan MacDiarmid and Hideki Shirakawa were rewarded for their work on conductive polymers, discovered in one of the classic cases of scientific serendipity when a student of Shirakawa's in Tokyo added too much catalyst in a standard synthesis of polyacetylene. What came out was plastic electronics, LEDs and solar cells, all of which might be manufactured cheaply and on a massive scale by printing technology.

The physics award went that year to Zhores Alferov and Herbert Kroemer for developing the semiconductor heterostructures now ubiquitous in information technology and telecommunications, and to Jack Kilby, who made the first integrated circuit at Texas Instruments in 1958. Kilby's award is particularly thought-provoking. You can watch a video of his Nobel lecture online, as you can for all winners since 1999. And it is of course Kilby's invention that set in train the technological advances that make this possible. One can't help fantasizing, as one scans down the lists of laureates, about that option being available earlier — what it would have been like to see Crick and Watson receive their awards, let alone Einstein, Bohr, Rutherford and Curie.

There is certainly scope for Nobel dreams, then, among solid-state materials physicists, who might also draw inspiration from the 1987 award to Bednorz and Müller for the discovery of high-temperature ceramic superconductors. Perhaps one day photonic crystals will squeeze in here. In chemistry, polymers are indeed a fruitful area, as testified by Staudinger, Ziegler and Natta, and Flory. And it would be wholly appropriate if carbon nanotubes were to be rewarded in the wake of the 1996 award to the discoverers of C_{60}, for nanotubes are surely the pre-eminent form of nanocarbon today.

But who will celebrate shape-memory alloys, biomimetic materials, superplastic ceramics, rechargeable lithium batteries? Where is there a way publicly to celebrate this kind of great 'stuff'?

Philip Ball