One, two, three... STM

It's as easy as one, two, three... (from left to right) Robert Sum, Dominik Müller and Lukas Howald, three entrepreneurial postdocs holding three items needed for easy STM: a box of electronics, a PC running Windows software and the device itself

Three young postdocs from Basel in Switzerland have built the world's smallest Scanning Tunnelling Microscope. It can be used on any desktop and can be plugged into any PC laptop. It is safe to use (it doesn't need high voltages) and, as the three entrepreneurs have set up their own company to market it, is selling at an affordable price, *writes Toby Chapman.*

It completes the move of STMs from machines found in physics basements to devices available in the physics classroom. "There was quite a lot of potential to simplify the existing designs [of STMs]. And we made quite a big step in this direction," says Lukas Howald, one of the three entrepreneurs.

The device itself, about the circumference of a petri dish, is small enough to be gripped with one hand, and weighs a kilogram. It sits on a soft rubber mat which in turn sits on a 2 kilogram slab of granite with short foam rubber legs. The rubber mat absorbs high frequency vibrations and the foam legs protect the device from low frequency – that's it as far as steadying the device goes.

But even with such basic damping the device works fine. Exhibiting their product at a microscopy conference in Hamburg last year, they set up the STM on the table provided and, "We had atoms for a week. Everyday we showed atom measuring and people were amazed to see it on just a simple table without damping. Everybody was very astonished that it works," says Robert Sum, another of the postdocs.

It is the perfect classroom device. Heiri Schenkel, a physics teacher at a Basel school which bought the first manufactured device five months ago, confirms this: "I was astonished to see how students got along – better than I." His 17 to 20-years old students are not just looking at pictures of atoms, they are making their own STM tips as well. "Students, after a very short introduction, are able to make their own tips and get images," he says.

But what makes this STM a real classroom gem, is the cost. An industry rival (Burleigh in the US) makes a so-called educational STM costing 20,000 to 25,000 Swiss francs. The team of postdocs's device is a mere 9000 Swiss francs, putting it within reach of at least the wealthiest of European schools. And the device is so rugged and portable, any school or university could make use of it easily.

The small group of postdocs, Howald, Sum and Dominik Müller met at the university in Basel. Two of them studied physics, while Müller was an electronic engineer. Their project for creating a compact and cheap STM was a private one, but naturally benefited from their research expertise.

Howald's expertise, for instance, led to using a clever design for a small stepper motor which moves the sample forward – a small bending filament replaces the gear-driven stepper motors of larger STMs.

In the new design, the sample (graphite and gold thin film samples are provided) is attached to the end of a small metal cylinder. The cylinder lies snugly in a trough, gently held there magnetically, but resting on the small filament that can bend. The filament is fed a sawtooth current so that it bends slowly then flips back. Every slow bend pushes the sample cylinder forward micron by micron.

The cylinder can be pushed forward by hand at first, then moved by the filament at the click of a mouse. As the sample gets near the STM's tip – just visible to the eye as a tiny wire – the electronics takes over, guiding the final approach until a nanoampere tunnelling current is sensed.

The movement of the sample is very easy to see – another reason apart from cost why the device is good for the class-

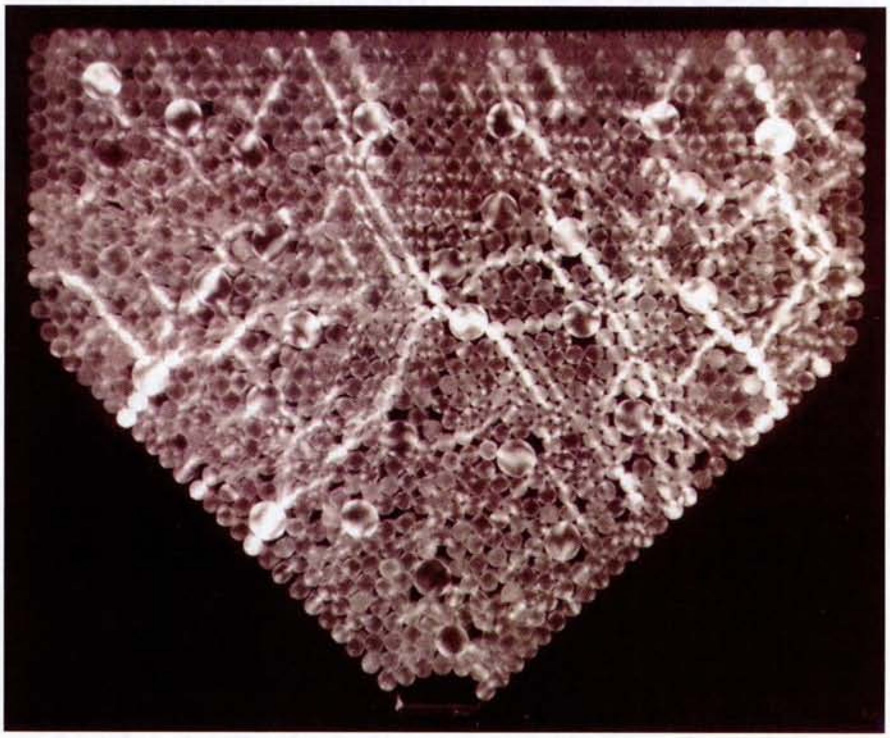
Desktop setup: the three rugged and affordable devices in action

room. The STM setup connects to a serial port on a PC, and atomic images appear on a computer running Windows – the team have written their own software.

And how do images from this small device compare with images from the big guys? They are the same resolution (the device was optimized for good atomic resolution), produced slightly slower and over slightly less surface area – but neither of these two sacrifices particularly worry the team. Their next project is to design an atomic force microscope, which will have a larger scan area and will, they hope, be useful to industry (such as thin film manufacturers) where seeing scratches on a surface is more important than the ability to see atoms.

The team have been helped so far by a start-up grant from the Swiss government, which has funded the project for a-year-and-a-half and has six months remaining. The start-up deal included business advice, and the team have been running a company (called Nanosurf) from a converted garage in Liestal just outside Basel since July of last year. Their achievement suggests that aims like 'smaller', 'cheaper' are general principles, and need not be reserved for sending rockets to Mars.

Nanosurf has a Website at www.nanosurf.ch.



Left a photoelastic view of a disordered packing of cylinders. The packing, in which disorder is due to the presence of large cylinders, sits in a two-dimensional hopper, a laboratory version of the cone-shaped hoppers that dispense grain in mills. The picture illustrates that in a granular medium the stresses are transmitted by a 'network' (the bright lines) which ignores a large number of grains. *Photograph courtesy Daniel Bideau, University de Rennes I*

Jam Session

The generosity of the Institute for Theoretical Physics at the University of California, Santa Barbara, enabled many European physicists to grab some winter sunshine late last year while participating in an extended workshop on "jamming". This does not connote impromptu theorising (although there was plenty of that) but rather the chosen subject: the stability and dynamics of granular materials, *writes Denis Weaire.*

Mud, sand, a bag of marbles, a grain-dispensing hopper, the fluidized beds of powder in industrial plants; all challenge the intuition and expertise of the condensed matter physicist. How precisely do they become jammed in equilibrium, or unjammed when forced to flow?

Ever since Osborne Reynolds strolled on the beach in 1885 and studied the imprint of his foot we have been aware that sand is not simple. (Reynolds observed that it dilates when it is sheared.) In the 1950s John Bernal set the style for much of today's research when he, rather simply, poured ball bearings into a bag and then scrutinised their arrangement. It was an unfashionably crude procedure at the time, but recent issues of leading journals have brought news of many variations on the theme, both for granular media and analogous systems such as wet foams. They reveal a strange distribution of forces in the pile, large internal avalanches under shear, convective flows induced by vibration, rising bubbles provoked by gas flow, and so on.

In most cases the physicist's quest for reductionism and the intriguing empirical facts (some long known to chemical engineers) have yet to find common ground. It's all as clear as mud.

A report of this meeting appears on page 58. Also, you can find slides and audio clips from a part of the jamming workshop (Constrained Dynamics on Microscopic and Macroscopic Scales, 12 to 16 October 1997) on the Internet at *www.itp.ucsb.edu/online/jamming2/schedule.html*

Further reading **HM Jaeger, SR Nagel and RP Behringer** *Rev Mod Phys.* **68** 1259 (1996)