Is a bell tolling for Bell Labs?

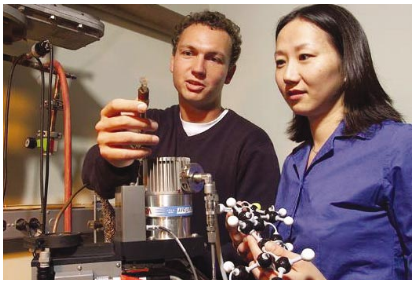
It would be wise of Bell Labs to help others reproduce their scientists' results.

Paul Grant

Dark clouds quickly began to gather over the exceptional finding of superconductivity at 117 K reported last year by Hendrik Schön and collaborators at Bell Laboratories in Murray Hill, New Jersey. Shortly after publication of the paper, I was asked by a reporter aware of my reputation as a sceptical observer of reports of 'unidentified superconducting objects' whether I felt uncomfortable that no one had reproduced any of the Bell Labs's field-effect transistor (FET) superconductivity results. My answer was: "Normally, I would be. But this is Bell Labs, and although these guys were my scientific adversaries for many years, I have the highest respect for their competence, credibility and, indeed, collegiality, and will accept their claims until proven otherwise."

Yet it has turned out that several attempts to reproduce not only these results, but also others on more general organic FET configurations, have been unsuccessful, culminating in allegations of duplication of data in several papers. Lucent/Bell Labs have set up a commission, headed by the internationally respected Malcolm 'Mac' Beasley, to examine the claims (see *Nature* **417,** 367–368; 2002 for an account of these events and for references). I hope this present imbroglio ends well for Bell Labs and its staff. For if not, we may indeed be hearing the final funereal tones from the halls of an already distressed US icon of science. To paraphrase John Donne, this bell will toll not only in Murray Hill, but throughout what remains of basic science research in industry.

Fabricating electrical contacts to conducting or semiconducting organic compounds is tricky. In the 1970s, in probably the first attempt to make organically based FETs, we at IBM's San Jose laboratory tried to form insulated-gate and Schottky barrier devices using lightly doped polyacetylene $(CH)_x$, to make an internal thin-film transistor flat-panel display. The insulated-gate FET configurations were polyacetylene films deposited on oxidized degenerate silicon as a gate, and junction FETs formed by indium or gold contacts to semiconducting $(CH)_x$. Both devices had weak transistor action, but not power gain as the 'barrier layers' were too conducting; yields were low and the lifetime of the barriers only a few days. After several attempts, we abandoned the effort — prematurely as it turned out, because a working organic FET was fabricated a few years later by a team at Cambridge (J. H. Burroughs, C. A. Jones & R. H. Friend, *Nature* **355,** 137–141; 1988). Several such devices now exist, including, presumably, those of the Bell Labs group.



LUCENT TECHNOLOGIES

Difficult times for Hendrik Schön and colleagues.

Perhaps even more germane to the difficulties of reproducing the results of Schön *et al.* were IBM's attempts to develop a thermal-transfer printing technology in the 1980s based on conducting polymer ribbons coated on one side with aluminium. Current was passed from a tungsten point contact on the bare side of the ribbon through the conducting polymer to the aluminium film, with the heat dissipated in the ribbon melting plasticized ink on the other side of the aluminium onto the paper. Print resolution was much better than we expected. It turned out that the interface between the aluminium and the conducting polymer was behaving as a Schottky-like barrier, which focused the current right underneath the point-contact print head. The interface between the aluminium and the conducting polymer was actually an unstable aluminium hydroxide layer displaying a highly non-linear current–voltage characteristic with a very high local electric field that sometimes quickly broke down and depended on ramping of the applied current. The hydroxide layer arose from minute amounts of water primarily responsible for the 10^{-6} torr background found in most vacuum systems used to deposit aluminium.

On 28 May this year, Schön circulated a preprint "Sputtering of alumina films for field-effect doping", apparently intended to guide people trying to reproduce his experimental conditions. Although his barriers are formed by sputtering Al_2O_3 and not by thermal evaporation of aluminium, the background pressure of the system is in the same 10^{-6} range where water vapour is the major component. The presence of aluminium hydroxide in plasma-deposited films of alumina has been documented (J. M. Schneider *et al. Appl. Phys. Lett.* **74,** 200–202; 1999) and is a source of some of the concern over the variability Schön reports in sample yield and lifetime. But it might also be the source of the magic that makes the devices work. There is a vague implication in Schön's preprint that only one sputtering unit has been used or has successfully produced functioning samples. If true, it would be a good idea to instrument that system to record all reasonably pertinent parameters in trying to build an exact copy.

AP

Tried and tested: silicon-chip manufacture.

The republic of science

Michael Polyani famously held that the practice of science is governed by a republic, a loose confederation of individuals bonded by the common goal of consensus on what determines when a particular 'truth' has been uncovered. In the republic of science, such truth is open to examination by everyone competent in whatever techniques are relevant to its determination. In more prosaic terms, if you're playing the sport of experimental physics, someone else had better reproduce your results or you're out of the ball game. If you've got an exciting result that may send you to Stockholm, the next thing to do, after you've established publication and patent priority, is to get your worst competitor to reproduce it, helping where necessary. Your management shouldn't have to set up a special commission to pore over your notebooks and files.

In the present instance, the issue is clearly one of samples. Traditional apparatus — batteries, potentiometers, lock-ins and *x-y* recorders — are all that is needed to measure electrical properties. Even if 'good' samples appear infrequently and are ephemeral when found, they can be taken to the lab next door and tested there. Even better would be transferring everything to another appropriate laboratory for replication. Setting up the Beasley commission is OK. But I believe an even more effective and decisive move would be for the leadership at Bell Labs to issue a 'grand challenge' to other suitable institutions to duplicate independently the extraordinary reports from their staff over the past two years, and to assist them to do so, thus showing that they are indeed good citizens of the republic of science. ■

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