THE ART OF MAINTENANCE

Perhaps the most remarkable thing about the all-purpose repair material Sugru — a hand-mouldable, durable silicone elastomer that cures in air at room temperature — is that the idea came not from a materials scientist or engineer but from a design student, Jane Ní Dhulchaintigh, a postgraduate at London's Royal College of Art. Rather than filling the world with more stuff, however beautifully designed, she felt there was more benefit in a means of extending and modifying the use of those that already exist. Sugru became first a cottage industry and then, once included in the top inventions of 2010 by *Time* magazine, a product with a cult following worldwide.

Naturally, Sugru could not have been developed without the assistance of materials scientists. Ní Dhulchaintigh was helped by two retired scientists who had previously worked on silicones for Dow Corning. The team experimented for seven years to develop a material with the required properties such as adhesion, setting time and plasticity.

Unlike many adhesives and fillers, a repair made with Sugru is highly visible — the material's bright colours are chosen to ensure that. The point is not to hide repair as an unfortunate or inconvenient necessity, but to advertise it as a virtue.

The common preference to keep mending as invisible as possible doubtless stems from a long tradition of regarding repair with suspicion: if this object has already needed mending once, how long before it fails again? That has probably contributed to a downgrading of maintenance skills: as David Edgerton points out in *The Shock of the Old*¹, a clear hierarchy has evolved with the professional engineer on top and the lowly repair worker below, which does not necessarily reflect their relative abilities.

The reason why repair should be seen as aesthetically unpleasing is even less clear. Until rather recently, most artefacts (from cars to clothes) got repaired many times, so that was just how things looked. Sometimes mending acquired its own artistry: in repairing Japanese ceramics, the aim was “to use the injury as the central element for the metamorphosis of the damaged ceramic into an object imbued with new characteristics”² — some joins were a lacework of gold.

In materials science repair is becoming modish again, but with workshop and artisan replaced by material autonomy: the substances, whether polymers, ceramics or metals, heal themselves^{3,4}. Much of the impetus for this research is bio-inspired, not least because none of us would be here but for the self-repairing capability of

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our tissues. There's plenty in nature to aspire to, such as the possibility that self-repair not only makes good the damage but reinforces against its recurrence.

Yet the case of Sugru illustrates not only that there is value still in low-tech solutions (or high-tech ones that anyone can use), but also that we might want to think more positively about repair: not as an embarrassing problem to be fixed quietly and out of sight, but as an opportunity and an objective that, in an age of material economies, can be celebrated. □

References

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SINGLE-ATOM DEVICES

Quantum engineering

A series of breakthroughs is making the fabrication of single-atom devices possible. Their behaviour is controlled by the quantum state of single dopants, and they hold promise for applications such as quantum bits, magnetometers and memories.

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In 1959, Richard Feynman famously gave a lecture he entitled “There is plenty of room at the bottom”¹, and posed a question that has inspired scientists and engineers ever since: “whether, ultimately — in the great future — we can arrange the atoms the way we want; the very *atoms*, all the way down!” The striking results presented at the

symposium ‘Single Dopant Semiconductor Optoelectronics’ at the 2013 MRS Spring Meeting in San Francisco are providing a positive answer to this question, with encouraging implications for the future.

Different strategies for controlling matter at the atomic scale are available. The so-called single dopant transistor²,

for example, is conceptually identical to the billions of field-effect transistors that operate in everyday electronic gadgets. In such devices the silicon region that separates the source from the drain is doped with thousands of donor atoms. The push to shrink the size of the transistor also implies a reduction in the number of dopants. Using