

Professor John Cave from Middlesex University introduces an exciting new material for technologists and designers.

Quantum Physics

in Design and Technology!

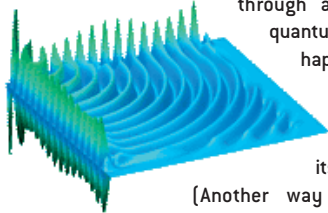
Despite increasingly rapid advances in technology, rarely do we see the emergence of an entirely new material. Quantum tunnelling composite (QTC for short) is a very recent creation - and all the more remarkable because TEP is able to make it available to schools just a couple of years after its discovery.

What is QTC?

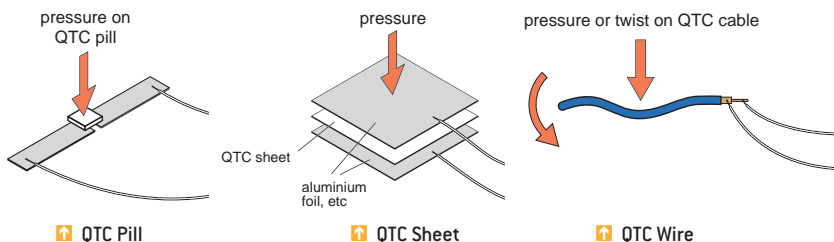
Quantum tunnelling composite is a flexible polymer that exhibits extraordinary electrical properties. In its normal state it is a perfect insulator, but when compressed it becomes a more or less perfect conductor and able to pass very high currents. Other plastics loaded with carbon are partially conductive and can be used to sense pressure. But they still only conduct minute currents by a process called **percolation** - the effect of carbon particles touching together within the plastic. In QTC, the change from non-conductor to conductor is dramatic, and a tiny piece measuring 4mm square and 1.5mm thick can pass a current of up to 10 amps when squeezed.

How does it work?

Instead of carbon, QTC contains tiny metal particles, but it does NOT work by percolation since the particles remain insulated by the plastic. Instead, electrons pass through the insulation by a process called quantum tunnelling - hence the name of the material. To explain this effect, we have to appeal to quantum theory and think of the electrons as waves. In classical physics, the electrons cannot pass through an insulation barrier, but according to quantum theory a wave can - and this is what happens in QTC. To some extent we have to suspend belief, because the world seen through quantum theory appears so much at odds with its common sense counterpart.



[Another way of describing the quantum tunnelling effect is to say that a probability exists of electrons at point A - one side of the insulation barrier - appearing at point B - the other side. This is all very weird - but demonstrably true.]



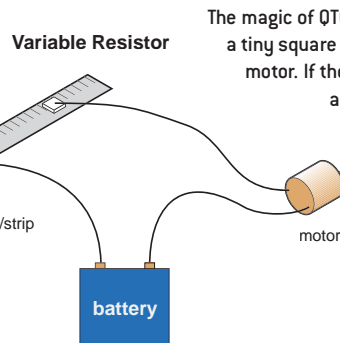
Applications of QTC

Since its discovery, QTC has passed quickly from a laboratory curiosity into a commercial product poised to revolutionise product design. It has already been used to make smart garments that can be wired directly to electronic products such as an iPod. It is also being retro-fitted, for example, within conventional switches to eliminate arcing and electrical noise. However, the material is so new that the commercial world is only just waking up to the vast number of new possibilities and applications. These include advanced membrane panel switches, speed controllers and sensors. When QTC is heated or comes into contact with reactive materials, its dimensions change slightly to bring about a measurable change in resistance. Because of this property, it can even sense small concentrations of organic molecules in liquid or gas form.



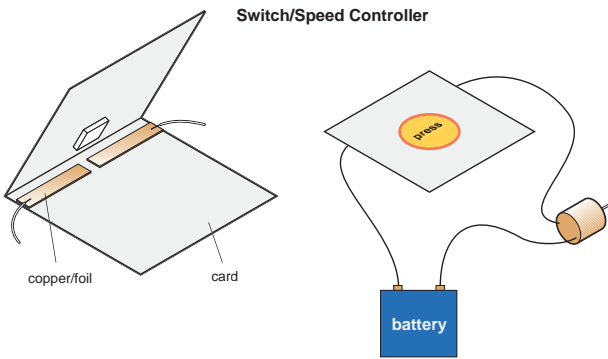
QTC in design and technology

In design and technology QTC has some immediate uses, and it is highly appealing to think that schools will be working at the same time as industry to explore as yet unknown practical applications.

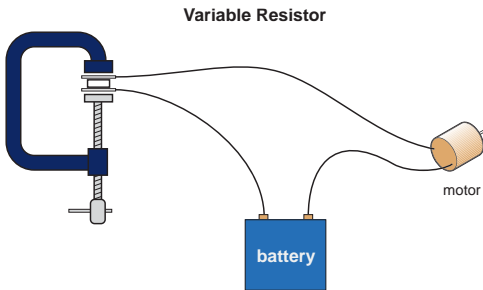


QTC is currently available in three forms: pills, thin sheet or cable - samples of which are contained in a low-cost TEP starter pack. Each form of QTC offers different possibilities for practical use, but all exhibit striking resistance change when deformed by squeezing, pulling or twisting. In practice, the different forms of QTC can be connected in quite simple ways to create anything from switches to force sensors.

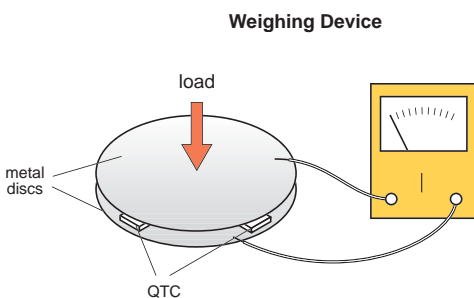
Example applications of QTC using pills



A QTC pill bridges the gap between two pieces of self-adhesive aluminium foil laid near the 'hinge' of a piece of folded card or plastic sheet. When the card above the pill is pressed, it acts either as an on/off press switch or a variable resistor. Many other card/pill configurations are possible including warning switches and alarms.

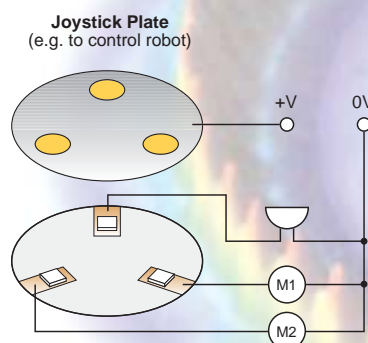


Controlled and sustained pressure on the QTC pill via a screw or lever system turns it into a potentially useful variable resistor for heavier currents. In this context, the alternative is an expensive wire-wound resistor with a rating above 1 watt.

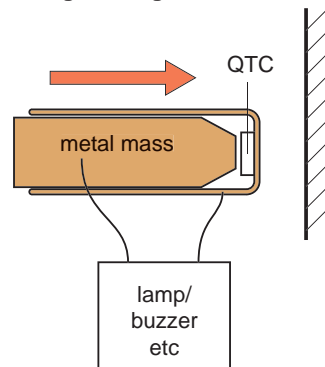


Three QTC pills placed between a pair of metal plates provide the basis for a weighing machine: The greater the load, the smaller the measured resistance. The resistance change can be read directly from a meter or fed to a PC with interpretative software.

If three pills are placed on separate self-adhesive foil strips on a card or plastic disk and overlaid with a metal plate, the weighing machine becomes a 2D joystick. Apply pressure evenly and all three pills 'turn on'. Apply more pressure to one side and the resistances change accordingly. The example shown will control the movement and direction of a two-motor buggy or robot, with a third 'channel' for a light, buzzer etc.



Impact Warning/Braking Indicator



Movement or force sensors become possible when one or more QTC pills are placed between a relatively large mass and a 'reference' surface. The example shown is a simply braking indicator consisting of a metal mass able to slide within a plastic tube. If the tube is moving and suddenly slowed down, the mass will exert pressure on a QTC pill and change its resistance.

What next?

Few materials as exotic as QTC have reached the classroom so quickly, and few would have expected pupils soon to be saying 'I did it with quantum tunnelling'. The QTC examples given here only begin to scratch the surface of what is possible with pills alone and many more examples will appear in future issues of News and Views. In the meantime, literature supplied in TEP's starter pack provides more applications for pills as well as example applications for QTC sheet and cable. Please try it out, and get back to us!

QTC starter pack (stock no QTC 004)

Contains a sample of each of the three forms of QTC and instructional literature. It also includes an electric motor, battery box connecting leads and self-adhesive foil tape.

- QTC pills – stock code QTC 001
- QTC sheet – stock code QTC 002
- QTC cable – stock code QTC 003

To obtain any of these products, please contact Teaching Resources on:

Tel. 01992 716052
Fax. 01992 719474
Email sales@muventures.co.uk

OR visit the website at www.mutr.co.uk

