Smart uses of QTC

Quantum Tunnelling Composite (QTC) was first produced in 1996 and has proved to be a very versatile pressure sensor as its resistance changes from the order of 1012 Ω to 1 Ω when pressure is applied. It can be directly interfaced to electrical and electronic devices. Carbon composites have been known about for many years. Traditionally their resistance changes with pressure but only by a factor of about a hundred. The deformation required to cause a factor of ten change in resistance is significantly greater than for QTC. QTC is therefore more sensitive to changes in pressure. Unlike QTC, composites cannot be regarded as insulators when no pressure is applied, so they cannot be used as switches. These unique properties have enabled QTC to be used as a sensor in a wide variety of applications e.g. electronic blood pressure and respiration rate monitors. Interactive whiteboards are sensitive to pressure and make use of QTC. A variable speed drill makes use of the decrease in resistance of QTC with pressure applied to it. The tighter the handle is gripped the faster the drill turns. Prosthetic hands that are sensitive to touch have a sensing skin of QTC.

This novel material is used in sportswear to monitor foot pressure distribution while running and to register a scoring hit when an opponent's sword has touched the jacket of a fencer. In terms of Curriculum for Excellence these activities are of relevance to the Learning Outcome - *Novel materials & their properties* **SCN 4-16a**

Here we illustrate the use of QTC to control the motion of an MFA buggy using simple QTC switches, as well as a design for buzzing flip-flops that can sense pressure on the soles of the feet.

Using QTC switches to control the motion of an MFA buggy

- pellets of QTC, 2x
- flexible plastic sheet (3x6 cm)
- sheet of craft foam (3x6 cm)
- aluminium piece (3x6 cm)
- 1.5 V batteries, 4x
- battery holder for 4x AA batteries
- battery connector.

Buzzing shoes

Using a pair of flip flops, a buzzing shoe can be very easily assembled at low cost.

All you need is:

- pair of flip flops with the straps removed
- buzzer, 3 V dc x2
- aluminium squares, 4 x (3 x 3 cm)
- battery holder x2 for 2 x AA batteries and 4 x AA batteries
- 4 pellets of QTC
- Corriflute
- Velcro 20 cm width, 140 cm length
- sheet of craft foam
- pair of pointed scissors and a craft knife
- Elastic 0.5 cm width, length 48 cm

Place the flip flop on top of the one of the pieces of Corriflute and with a felt tip pen mark the position of the battery holder, the position of the two holes in the flip flop that the straps went through at the heel end of the flip flop and the single hole at the toe end on the Corriflute. Use the scissors to cut away the top layer of the Corriflute where the battery is to be (see Figure 5), this indent will keep the battery holder in position.

This piece of Corriflute forms the sole of the shoe. Cut 2 cm slits starting at the position of the holes in the flip flop at the heal end and going towards the toe end and either side of the single hole 2 cm from the edge of the Corriflute at the toe end as indicated in figure 5. Cut slits in the same position in the flip flop and in the top layer of Corriflute. These slits are for the Velcro to be threaded through.

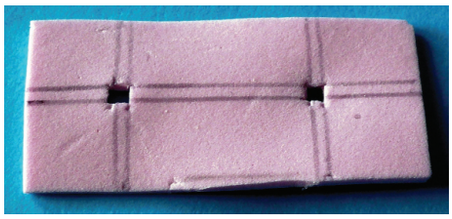

Figure 1 *- Cut a 3x 6 cm piece of foam and mark on 3 x 3 mm squares for the QTC pellets 1.5 cm from each end and from each side. Using a sharp pair of scissors cut out the squares in the foam sheet. Insert one QTC pellet into each of the square holes.*

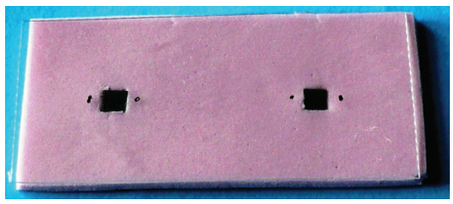

Figure 2 *- Lay the plastic sheet on top of the foam sheet and mark the position of the holes for the connecting wires so that the wires are centrally located either side of each of the QTC pellets.*

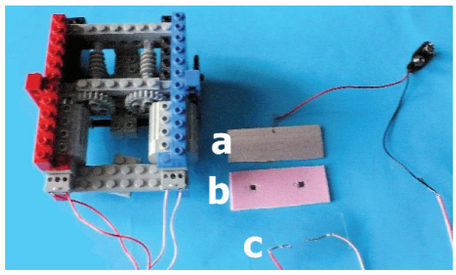

Figure 3 *- Make a hole in the aluminium sheet 0.5 cm from one side and 3 cm from each end (a) and thread the bare wire from the battery connector through it. Fold the wire back and twist the wire round itself, or solder, to make a good electrical connection. Make holes in the plastic at the positions indicated so they are just large enough for the wire to pass through. Take one wire from each of the motors and strip 1.5 cm of wire from the end of each. Thread one of the wires from each of the motors through the holes in the plastic as shown in (c).*

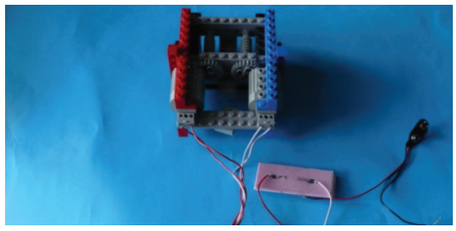

Figure 4 *- Place the plastic sheet over the foam sheet, ensuring the QTC pellets are located under each wire, put the 3 x 6 cm strip of aluminium under the foam and wrap Sellotape round them to hold the layers in position. Connect the other wire from the battery connector to the other wire coming from each of the motors by twisting all three wires together or soldering them together. Connect the battery holder to a 6 V supply. On pressing the plastic above each of the QTC pellets, the motors can be turned on and off and their speed controlled so the buggy can be steered around a course.*

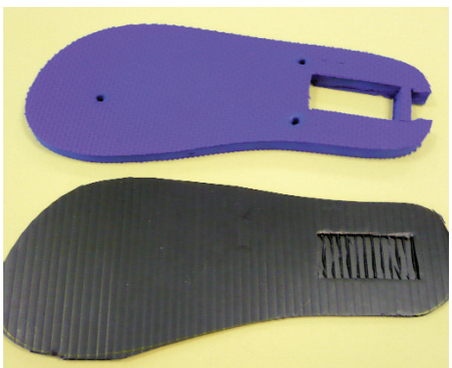

Figure 5 *– Lay one of the flip flops on top of the Corriflute, draw round it and using a craft knife cut out the shape of the flip flop in Corriflute. Repeat this so you have two identical pieces of Corriflute.*

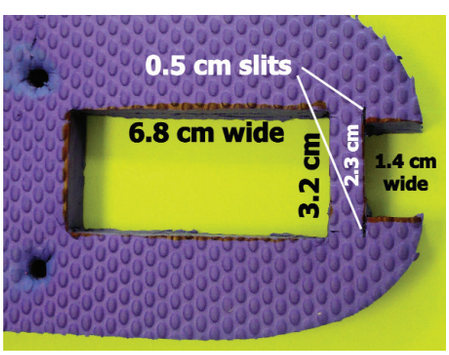

Figure 6 *– At the heel end of the flip flop cut out a 2.3 x 1.4 cm shape for the buzzer to fit in. The buzzer has two mounting sockets, to accommodate these cut two slots 0.5 cm in length. The slots will hold the buzzer in place. One centimetre from the buzzer opening cut out a rectangle 6.8 x 3.2 cm for the battery holder.*

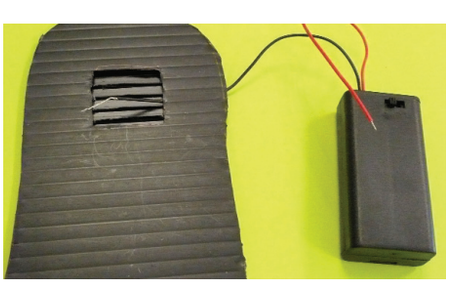

Figure 7 *– Take the second piece of Corriflute and on the side next to the flip flop 1 cm from the heel end of the battery holder position, mark out a 3 x 3 cm square and cut away the top layer of the Corriflute so that one of the pieces of aluminium just fits into the cut out square. This ensures the QTC switch is below the on off switch for the battery.*

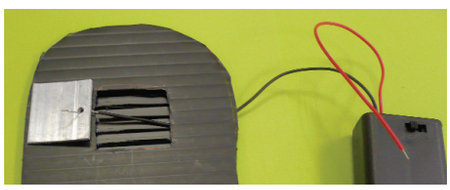

Figure 8 *– Strip 2 cm of wire from the black wire on the battery connector and thread the wire through the Corriflute as shown. Thread the wire through the hole in the aluminium square and twist it around itself or solder to make a good electrical connection.*

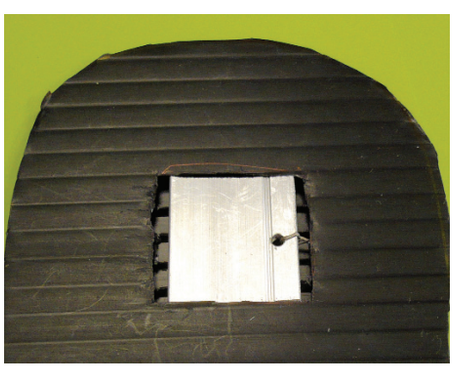

Figure 9 *– Place the aluminium square in the square cut out for it in the top layer of Corriflute.*

Figure 10 *– Strip 1 cm from the end of the red wire attached to the battery and 1 cm from the end of the red wire attached to the buzzer, twist or solder these bare wires together to make a good electrical connection. Strip 2 cm from end of the black wire connected to the buzzer then thread it through the hole in the second 3 x 3 cm square of aluminium. Twist the wire round itself as described previously or solder to make a good electrical connection between the buzzer and the second sheet of aluminium.*

Figure 11 *– Cut a 3 x 3 cm square piece of foam. Cut a 3 x 3 mm square hole in the centre of the square foam for two pellets of QTC to fit in, one on top of the other. Place the foam square on top of the aluminium square located in the Corriflute.*

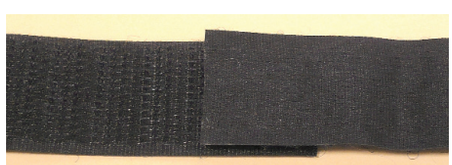

Figure 12 *- Cut a 35 cm length of Velcro. Pull the Velcro apart and rejoin the ends so they stick together. Place the join under the bottom piece of Corriflute half way between two of the slits closest to the heel end.*

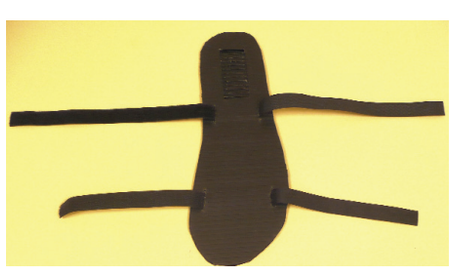

Figure 13 *– Slot the Velcro through the slits cut in the bottom layer of Corriflute then slot the Velcro through the slots in the flip flop.*

Figure 14 *– Thread the Velcro through the slots cut in the flip flop.*

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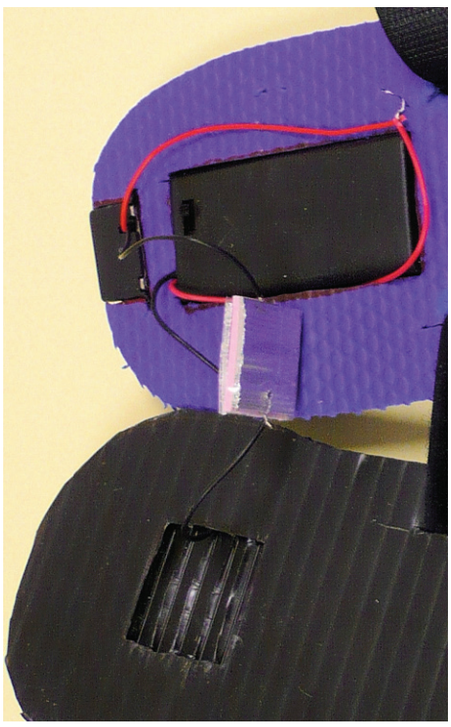

Figure 15 *– Push the battery holder into the space cut out for it in the flip flop and push the buzzer into its slot at the heel end. Sandwich the pink foam, with the two QTC pellets embedded in it, between the two aluminium squares. Ensure that the wire connections are on opposite sides of the square so that no shorting out is possible. Hold them together using Sellotape. Check the buzzer functions by switching on the battery and squashing the aluminium plates together. If no sound is heard, widen the top half of the slits to allow enough space for the vibrations of the buzzer, keeping the bottom of the slits narrow so the buzzer is held in place.*

Figure 16 *– Push the aluminium square sandwich into the square insert cut in the top piece of Corriflute and Sellotape it in position. Thread the Velcro through the slits in the top piece of Corriflute and pull it through so the two pieces of Corriflute and the flip flop are held firmly together.*

Figure 17 *– Cut a 24 cm piece of elastic and sew each end of the elastic to the Velcro on either side of the shoe at the heel end, 5 cm up from the top layer of Corriflute.*

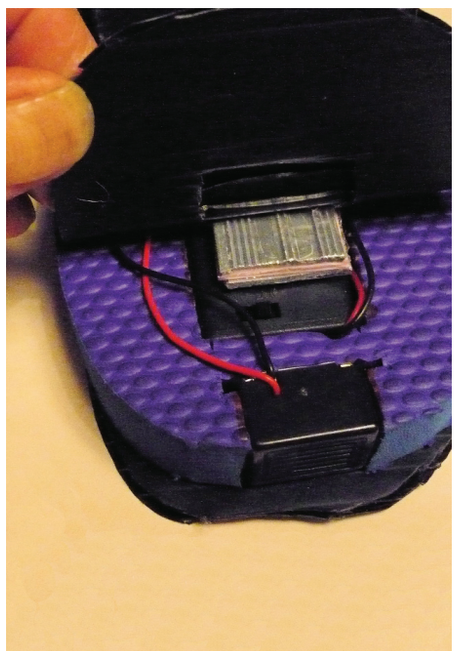

Figure 18 *– Lift up the section of Corriflute at the heel end and switch on the battery.*

Figure 19 *– Attach the shoes to your shoes using the Velcro fastening. Walk along and every time pressure is applied to the heel a buzzing sound will be heard. Remember to switch the battery off after use.*

Further reading

More detailed theory http://www.peratech.com/qtcscience.php
Applications of QTC http://www.peratech.com/qtcapplications.php

Component	Source	Product code and price
QTC pellet	www.mutr.co.uk	QTC 001, £0.15 per pill
Battery holder	www.mutr.co.uk	EC1035, £0.26
3 V d.c. Buzzer	www.mutr.co.uk	EW2 002D, £0.62

[1] For advice on safe soldering, see: http://www.sserc.org.uk/members/SafetyNet/bulls/199/3-4.htm

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