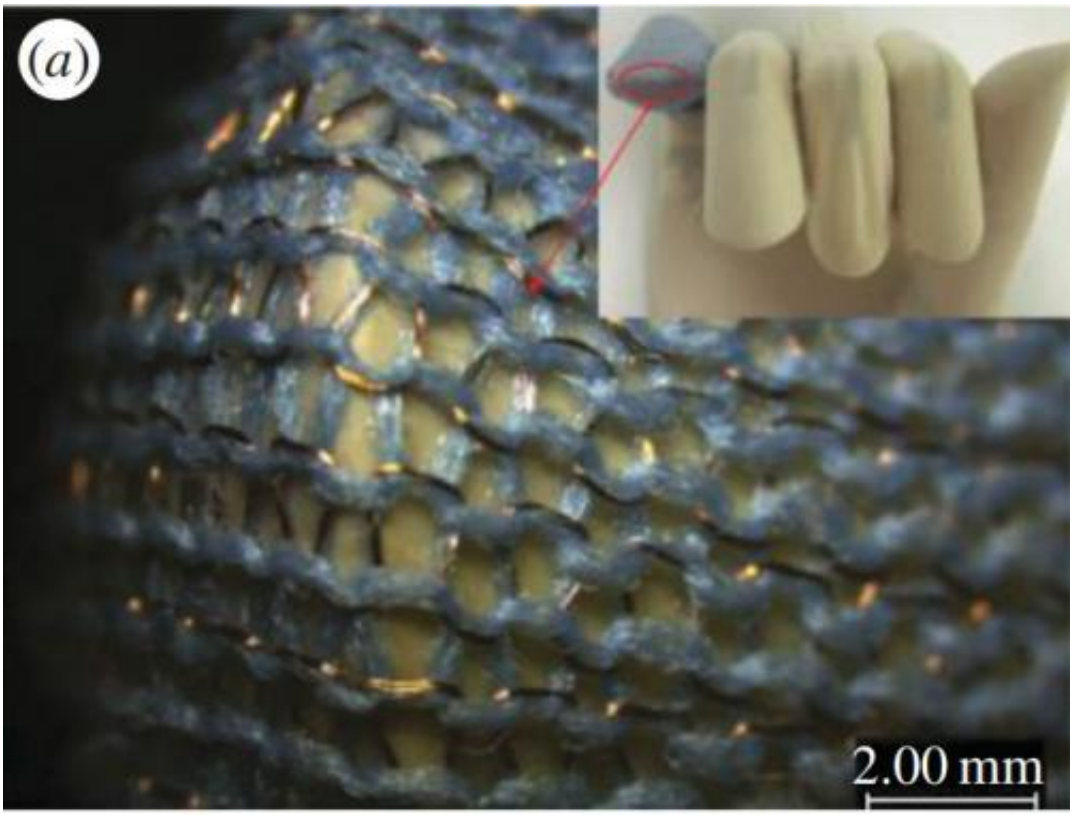
Fabric circuit boards that can take bending, washing, stretching and bullets fired at them

September 4 2014, by Bob Yirka



Structure of a knitted FCB. Credit: *Proceedings of the Royal Society A* 8 November 2014 vol. 470 no. 2171 20140472. doi: 10.1098/rspa.2014.0472

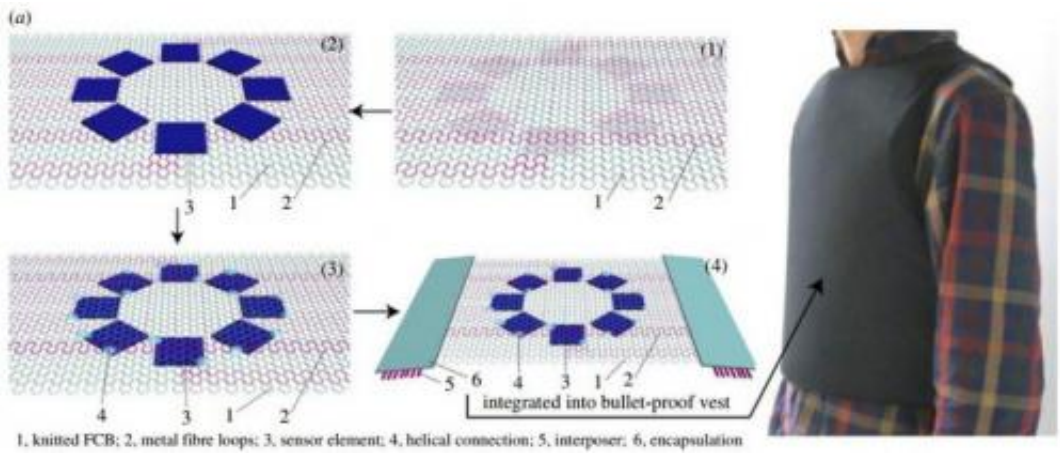
A pair of researchers at The Hong Kong Polytechnic University, has developed a computerized knitting technology that allows for creating fabric circuit boards (FCBs) that can take a beating and keep on working. In their paper published in *Proceedings of the Royal Society A:*

Mathematical, Physical and Engineering Sciences, the two describe how the new technology works and just how strong the resulting products can be.

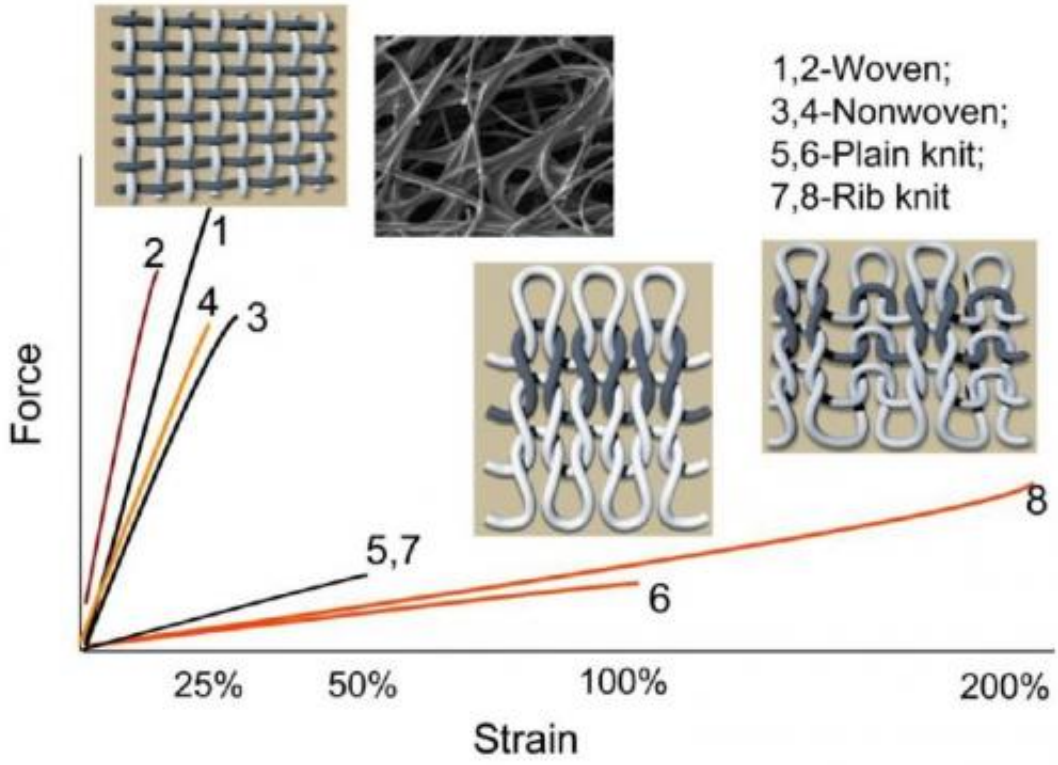
Making circuit boards that can take more punishment than those currently available would allow for whole new types of products—phones that don't break, wearable devices that are actually part of clothes, tougher police and military gear, etc. To make it happen, scientists have been looking to use new materials and processes for making them. In this latest effort, the two researchers in Hong Kong combined electrically conductive fibrous metal materials with normal fabric materials using new computerized knitting technology. The result is a three-dimensional material that can withstand stretching, being washed in a washing machine and dried in a dryer, being shot by a bullet (when under a bulletproof vest) and twisting—over and over. The team reports that not only can their FCBs take the punishment, they can withstand it over many cycles over long periods of time.

FCBs perform the task of directing electricity from one part of the garment to another, thus they offer mechanical support even as they electrically connect discrete electronic components. They can also be designed as single, double or even multiple layered structures, mimicking their traditional counterparts. To be used as a wearable device, they also have to low resistance, as compared to human skin, to allow for a reasonable degree of comfort and be washable to allow for removing both stains and odors.

The researchers claim their FCBs are ready for use—they're comfortable, durable and will last a long time. They could be used to create an entire shirt, for example, or a vest. Either could be used as a solar collector or as a multiple sensory device, recording heat, perspiration, heart rate, etc. In addition, their new knitting technology allows for stitching, weaving, knitting and embroidery.



Fabrication and application of a fabric sensing network integrated into a bulletproof vest. Credit: *Proceedings of the Royal Society A* 8 November 2014 vol. 470 no. 2171 20140472. doi: 10.1098/rspa.2014.0472



Mechanical properties of different textile structures. Credit: *Proceedings of the*

Royal Society A 8 November 2014 vol. 470 no. 2171 20140472. doi: 10.1098/rspa.2014.0472

More information: Three-dimensionally deformable, highly stretchable, permeable, durable and washable fabric circuit boards, *Proceedings of the Royal Society A* 8 November 2014 vol. 470 no. 2171 20140472. rspa.royalsocietypublishing.or … nt/470/2171/20140472

Abstract
This paper reports fabric circuit boards (FCBs), a new type of circuit boards, that are three-dimensionally deformable, highly stretchable, durable and washable ideally for wearable electronic applications. Fabricated by using computerized knitting technologies at ambient dry conditions, the resultant knitted FCBs exhibit outstanding electrical stability with less than 1% relative resistance change up to 300% strain in unidirectional tensile test or 150% membrane strain in three-dimensional ball punch test, extraordinary fatigue life of more than 1 000 000 loading cycles at 20% maximum strain, and satisfactory washing capability up to 30 times. To the best of our knowledge, the performance of new FCBs has far exceeded those of previously reported metal-coated elastomeric films or other organic materials in terms of changes in electrical resistance, stretchability, fatigue life and washing capability as well as permeability. Theoretical analysis and numerical simulation illustrate that the structural conversion of knitted fabrics is attributed to the effective mitigation of strain in the conductive metal fibres, hence the outstanding mechanical and electrical properties. Those distinctive features make the FCBs particularly suitable for next-to-skin electronic devices. This paper has further demonstrated the application potential of the knitted FCBs in smart protective apparel for in situ measurement during ballistic impact.

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