How **physics drives** the supermarket industry

- Supermarkets are worth more than **£100 bn** to the UK economy
- Physics technologies are at the **heart of modern supermarket checkouts** and stock-management systems
- To keep pace, supermarkets will need to take advantage of **pioneering new physics-based technologies**

The invention of lasers, combined with complex optical components developed by UK physicists, enables rapid and reliable scanning of barcodes

Touchscreens and electronic shelf-edge labels: physics-based technologies. iStock.

Courtesy of ZBD Displays Ltd.

Supermarkets are a UK success and are at the forefront of innovation in customer experience and product design. The strength of modern supermarkets is also built on the application of physics-based technologies, from electronic point-of-sale systems to self-service checkouts, and there is more to come.

According to one leading retailer, the technologies that physics enables are key to attracting and retaining consumers because they provide the convenience and ease of use that they have become accustomed to in other areas of life.

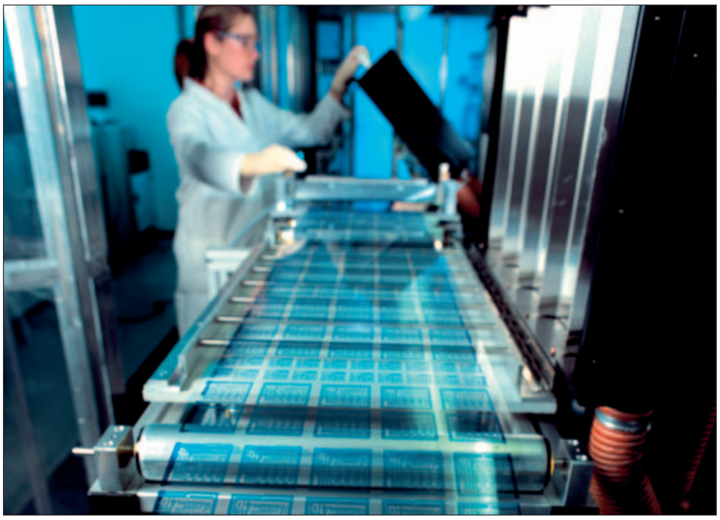
The speed and simplicity of supermarket checkouts can mean that it is easy to forget that they depend on the application of sophisticated laser equipment and high-technology optics.

Each time a product is scanned, the information encoded as a barcode is illuminated, and the reflected light is read, understood and processed in less than a second. The speed and accuracy of these systems is only possible because of the extreme properties of the laser light produced in the scanner.

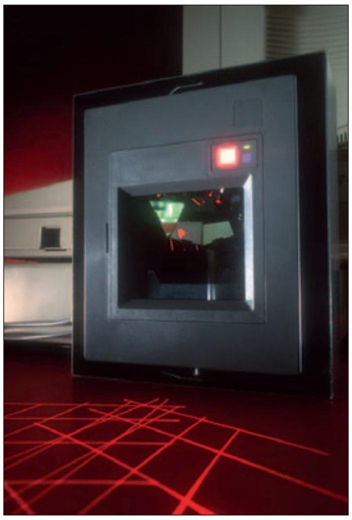
However, a laser alone is not enough. With only one laser beam and one detector, barcodes would need to be carefully aligned with the scanner to be read – a delicate and time-consuming process at a busy checkout. To make the system suitable for use in supermarkets, complex optics are used to split the laser beam into multiple components, projecting it at several different angles on the barcode allowing it to be read from any direction. Many modern checkouts contain rapidly rotating prisms, which split the beam, and numerous mirrors, which combine the reflected light at the detector.

The invention of lasers, combined with the complex optical components developed by UK physicists, enables rapid and reliable scanning of barcodes that would not be possible with other light sources, allowing the technology to be used in checkouts. Such laser scanners are at the heart of modern Epos systems, the speed and automation of the process allowing real-time updating of stock records and enabling efficient storage and transport of products.

"Retailers will increasingly use touchscreens… because they will be able to show things that there isn't room to show on the shop floor"
Michal Diakowski



Intelligent label chip manufacture. RFiD tags have the potential to put an end to queuing in supermarkets. Volker Steger/Science Photo Library.



Modern barcode scanner. iStock.

Einstein at the checkout

The lasers that are found in supermarket scanners have their roots in the work of Albert Einstein, who in 1917 predicted the phenomenon of "stimulated emission" of light – the ability of certain materials, under the right conditions, to produce very bright, uniform beams of light. Einstein's theoretical work was not put into practice until 1960 when American physicist Theodore Maiman produced the first visible light laser. For a long time this light source was treated as a scientific curiosity – a solution in search of a problem – but today lasers are found in everything from DVD players to builders' spirit levels. While Maiman had to use a large piece of ruby to produce his laser light, modern lasers can be made from semiconducting diodes: small, lightweight and efficient enough to fit in a handheld scanner.

Computer touchscreens are another physics-led development that is central to the success of modern supermarkets, allowing detailed product information to be literally at the fingertips of staff and customers alike. They have increased the efficiency of supermarket checkouts through speeding up identification and pricing, and have also allowed the development of "self-service" checkouts, which reduce queues and allow retailers to tackle issues of space. "Many different retailers will increasingly use touchscreens in their stores because they will be able to show things that there isn't room to show on the shop floor," according to Michal Diakowski, from touchscreen manufacturer U-Touch. The first modern touchscreen was created in 1973 by two physicists, Frank Beck and Bent Stumpe, seeking to find an easy way to control the high-energy particle beams at the CERN particle accelerator near Geneva (now the site of the search for the Higgs boson). Their invention built on decades of physics research into the electrical properties of materials and utilised capacitors contained within the screen itself to sense the position of a user's finger though the way it interacted with the screen's electric field.

Research and development on touchscreens continues to this day, with many different systems – ranging from pressure sensitive screens to those that detect light – suited to all environments, and they can be found everywhere from smartphones to jumbo jets.

In 2005, UK supermarket Asda installed its first self-service touchscreen checkouts, and by the end of 2011 they were in every UK store. "It is becoming the standard way we interact with technology, from phones and tablets to computers and checkouts – it is intuitive," explains an Asda spokeswoman. "As self-service checkouts have a smaller footprint than standard checkouts we are able to install more units in the same space, which is a real benefit."

RFiDs could... create a market estimated at more than $10 bn a year

From aircraft to aisle nine

Radiofrequency identification tags (RFiDs) are a means of storing and wirelessly transmitting information. The technology has its roots in electromagnetic theory and was first developed by the military in the 1940s for use in aircraft identification. Recent advances in semiconductor physics and material science have meant that modern RFiD tags can be millimetres across. An RFiD tag is made up of a microchip, which stores the information, and an antenna, which is used to transmit the data to an electronic reader. Tags used in retail and other areas, as detailed below, are "passive" – unpowered, but able to harvest energy from the radio waves transmitted by the reader as it scans the chip.

The future

Over the next decade new technologies developed from physics research will begin to appear in UK supermarkets. Perhaps the first to be noticed by customers will be electronic shelf-edge labelling.

ZBD Displays, a physics-based UK company, has developed a technology that removes the need for traditional paper labels and instead allows product prices and information to be shown on a novel liquid-crystal display. This allows the information to be updated wirelessly from a central computer at the touch of a button. Liquid crystals were first discovered in 1888 by Friedrich Reinitzer and Otto Lehman, who noticed that when certain plant extracts were heated they became a curious mixture of liquids and solid crystals. It was nearly 50 years until the Marconi Wireless Telegraph company took out the first patent on a liquid-crystal display, and the electronics revolution of the 1950s and 1960s before the devices became practical. Since then, LCD displays have become a part of everyday life. The display developed by ZBD is "bi-stable", only requiring power to change the information shown on the display, rather than to maintain the display, as is the case with conventional devices. This feature is "low cost but high performance", according to chief technical officer Cliff Jones, and enables the displays to have a long working life. The development of the technology involved "some quite deep physics", says Jones.

Even if the market for electronic shelf-edge labelling is as successful as some have predicted, it might still be dwarfed by that of another long talked about technology – radiofrequency identification tags (RFiDs). These wireless transmitters are currently used in payment systems such as the Oyster card used by Transport for London, and are being introduced by credit card companies to enable "contactless" payments. The tags could potentially be attached to all sorts of objects – food, clothing, electronic appliances – and could be used to hold information, as well as to track movement. RFiD tags attached to supermarket products could allow customers leaving a store to pass a sensor at the exit where all items in the trolley would communicate simultaneously and automatically with the store's reader. This could then debit the customer's bank account and automatically adjust the store's stock figures without the involvement of any staff and with no possibility of a queue forming. They are already being used by retailers such as Marks & Spencer to track and secure products through their supply chains – the company installed more than 3.5 million on transport crates in 2002.

However, current RFiD tags are expensive. They are made of silicon or conductive inks and cost a few cents each, compared with less than one cent to print a barcode, but advances in material science are beginning to drive these costs down. Nanotechnology researchers from Sunchon National University in Korea and Rice University in Houston have developed RFiD tags made of carbon nanotubes containing special inks that can be printed directly onto the outside of food packaging. This has the potential to reduce the price per tag to just one cent within the next two years. At that point the devices could be cheap enough to create a market estimated at more than $10 bn a year.

It seems clear that supermarkets and other shops will continue to make ever greater use of technology and that physics research and development will continue to underpin that technology.

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