

MILESTONE 14

Digital photography is born



The CCD inventors, Willard Boyle (left) and George Smith (right). Image courtesy of Alcatel-Lucent/Bell Labs

'Revolutionary' is used too often to describe advances in science. When applied to the invention of the charge-coupled device (CCD) array by Willard Boyle and George Smith, however, it is not far off. Yet, the CCD was not originally intended for applications in digital imaging, for which Boyle and Smith received the 2009 Nobel Prize in Physics, but rather as a potential new form of digital memory.

In the late summer of 1969, Boyle and Smith, who were working at Bell Laboratories, were told to come up with a semiconductor memory that could compete with the so-called 'magnetic bubble' memory that was being developed by a rival group of their division. Bubble memory

worked by injecting magnetic domains into garnet patterned with an array of ferromagnetic bars. Applying an alternating magnetic field caused these domains, or bubbles, to hop within the garnet from underneath one bar to the next, like packages on a conveyor belt. By taking the presence or absence of a bubble to represent a 1 or a 0, respectively, such a device could be used to store a series of digital bits.

Boyle and Smith spent barely an hour at the blackboard devising an electronic alternative. Instead of magnetic bubbles, they proposed to use electronic charges injected into metal-oxide-semiconductor (MOS) capacitors grown on silicon. By placing two capacitors close to

each other and applying electric voltages they could induce the charge to move from one to the next. In this way, packets of charge could be passed down a linear array of 'charge-coupled' MOS capacitors, mimicking the operation of a bubble array.

Ironically, although the operation of the device was a success, neither it nor bubble memory ever took off as a means of storing digital information. But it did not take long for Boyle and Smith to realize that it might have other uses. At around the same time, Bell Laboratories was working hard to develop the Picturephone, which was a crude videoconferencing system. The commercial cathode-ray-tube cameras used were notoriously unreliable and a more dependable alternative was eagerly sought. The CCD provided the solution.

The simplicity of fabricating large sensor arrays, combined with the linear optical response to even the most faint light sources, has meant that 40 years after their invention they are still used in large-scale optical telescopes, including the Hubble space telescope. It has also allowed them to become cheap enough to be integrated into most modern mobile phones — a fact that news agencies increasingly rely on for important events. So, although the revolution might not be televised, thanks to the CCD it will almost certainly be photographed.

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ORIGINAL RESEARCH PAPERS Boyle W. S. & Smith, G. E. Charge coupled semiconductor devices. *Bell Syst. Tech. J.* **49**, 587–592 (1970) | Amelio, G. F., Tompssett, M. F. & Smith, G. E. Experimental verification of the charge coupled device concept. *Bell Syst. Tech. J.* **49**, 593–600 (1970)

FURTHER READING Smith, G. E. The invention and early history of the CCD. *Nucl. Instr. Meth. Phys. Res. A* **607**, 16 (2009)