Fathers of electronic revolution are rewarded

Liesbeth Venema

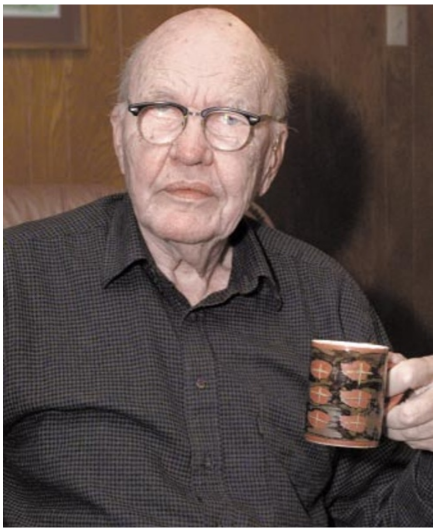
With the advent of the World-Wide Web and the mobile phone, the information society has truly arrived. This year's Nobel Prize in Physics honours three scientists whose work laid the foundations for modern information and communications technology.

Half of the prize goes to Zhores Alferov of the Ioffe Physico-Technical Institute in St Petersburg, Russia, and Herbert Kroemer at the University of California at Santa Barbara for their work in developing semiconductor heterostructures, which have led to faster transistors and more efficient laser diodes. The other half recognizes Jack Kilby from Texas Instruments in Dallas, co-inventor of the integrated circuit.

Today's electronic devices are both small and fast — we want a mobile phone that slips into our pocket and laptops that fit into our briefcases. At the same time, we expect them to process information almost instantaneously. The three winners have all made major contributions to working out how to get the basic physical principles in small systems working to the advantage of the electronics industry.


EPA/AP

Alferov (left) and Kroemer: worked on transistors.


AP

Kilby: co-inventor of the integrated circuit.

The workhorse of electronics is the transistor, for which William Shockley, John Bardeen and Walter Brattain won the physics Nobel in 1956. But in the 1960s, Alferov and Kroemer started working on faster transistors, made from structures composed of thin layers of semiconducting materials. These layers can each be designed to have specific electronic properties, and it is the subtle interactions between the layers that give heterostructures their advantage over bulk silicon.

One major challenge was to have the layers perfectly matched to each other with atomically smooth boundaries. Alferov and Kroemer showed that transistors built in this way can switch very quickly. They are now in widespread use, for example in the base stations of mobile phone networks. The heterostructures can also be used as small light sources — laser diodes — examples of which are found in CD players or bar-code readers.

Semiconductor heterostructures have also turned out to be of tremendous importance for fundamental physics. The physics Nobel prizes in 1985 and 1998, for the discovery of the quantum Hall effect and the fractional quantum Hall effect — unanticipated quantum phenomena involving electrons confined within two dimensions — could not have happened without the development of semiconductor heterostructures.

Kilby's main contribution was in miniaturization, as his integrated circuits removed the need for bulky wiring to connect individual transistors. Starting in the late 1950s, Kilby at Texas Instruments and Robert Noyce of Fairchild Semiconductor Corp. in California showed separately that it is possible to etch integrated circuits into thin wafers of silicon. Noyce died in 1990, but Kilby has lived to see his invention become almost ubiquitous.

Laurence Eaves, who works on semiconductor devices at the University of Nottingham, says that researchers in the field will be delighted with the award. "It's a recognition of the basic physics and materials science that has led to the electronic revolution," he says.

In Russia, Alferov's award may be especially important, providing a valuable boost for a scientific community that has suffered immense financial hardship. Russian researchers hope the publicity will help win improved investment in basic science. When *Nature* called Alferov's St Petersburg's office shortly after the announcement, the publicity machine was already in full flow. "He has been seized by the mass media," an assistant explained. ■

Plastics that conduct win inventors chemistry prize

David Adam

The Nobel Prize for Chemistry has been awarded to Alan Heeger, a physicist at the University of California at Santa Barbara, and two chemists, Alan MacDiarmid of the University of Pennsylvania, Philadelphia, and Hideki Shirakawa of the University of Tsukuba, for their roles in the development of electrically conductive polymers.

The three winners established that polymer plastics can be made to conduct electricity if alternating single and double bonds link their carbon atoms, and electrons are either removed through oxidation or introduced through reduction. The extra electrons or corresponding 'holes' can then move along the 'doped' molecule, making the conjugated polymer conduct electricity almost as well as a metal.

Some 25 years after the initial discovery, conducting organic polymers — effectively acting as semiconductors — are now being developed for applications ranging from light-emitting diodes in electronic displays to cheap replacements for the silicon chip (see *Nature* 407, 442–444; 2000).

Shirakawa first stumbled across a new method of making *trans*-polyacetylene films in the early 1970s — a silvery film appeared when 1,000 times too high a concentration of catalyst was added by mistake. MacDiarmid and Heeger were also experimenting with a metallic-looking film of the inorganic polymer sulphur nitride. After the three met, they jointly discovered that iodine doping boosted the electrical conductivity of *trans*-polyacetylene 10 million times, and published the results in a seminal 1977 paper (*J. Chem. Soc. Chem. Commun.* 579; 1977).

Chemists and physicists have taken the field further since then — discovering that organic polymers can be induced to light up, for instance. Layers of these conducting polymers could help to create flat television screens or luminous traffic signs.

"I'm surprised, but I think it is wonderful," says Lewis Rothberg, a researcher into conjugated polymers at the University of Rochester, New York. "A lot of things that started with their discovery are not only of tremendous scientific interest but will also have a great technological impact." ■