major rivers. Turley and her colleagues have found that the phytoplankton are on average only one-third as abundant in the Mediterranean's eastern basin as in the west. And bacteria consume a far greater proportion of this plant material in the eastern Mediterranean than in the west.

When Turley and colleagues analyzed phytoplankton and bacterial growth in shipboard experiments, they found that 55% of phytoplankton production flows to the microbial food web in the west; in the east, this figure rises to 85%. "The fierce competition for scarce nutrients favors the smaller organisms, which are able to utilize them most rapidly," explains Frede Thingstad of the University of Bergen in Norway.

Because bacteria hog the phytoplankton, other organisms are disproportionately scarce. Fish production is just a third of that in the western basin. And because the bacteria also degrade organic detritus, the rain of organic particles into deep waters from the sunlit layers above is nine times lower than in the western basin, starving bottom-dwelling organisms. Their biomass is 46 times lower than in the western Mediterranean, according to Turley's analysis of experimental results.

At the National Center for Marine Research in Athens, Efstathios Balopoulos and his colleagues have traced a similar picture in the Aegean Sea, part of the eastern Mediterranean, finding that bacteria account for more than 56% of the organic particles in shallow layers. And because the bacteria consume nearly all the sinking waste matter, he found that the deep Aegean is one of the most meager habitats anywhere in the world ocean.

–Nigel Williams

MICROELECTRONICS

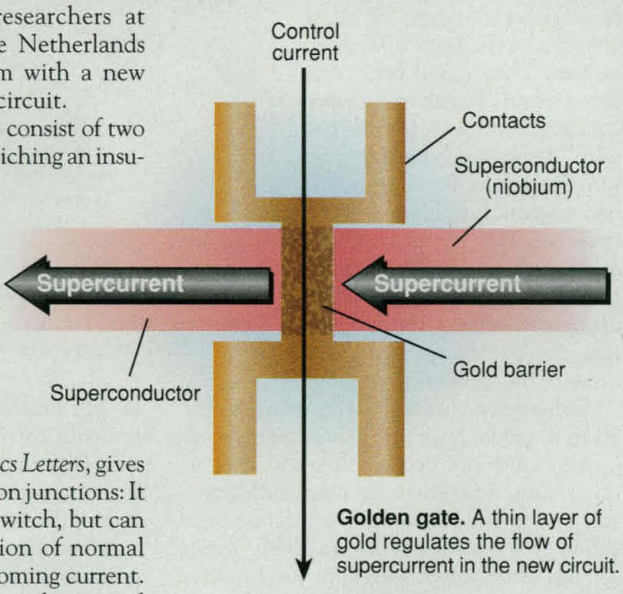
The Transistor With a Heart of Gold

The dream of superconducting circuits has never quite died. More than 10 years ago, most researchers abandoned hope for one kind of superconducting transistor, based on structures called Josephson junctions. But their disappointing performance didn't end the allure of circuits that would operate without electrical resistance—and hence might run much faster than conventional circuits and fit into a smaller space without overheating. Now, a team of researchers at Groningen University in the Netherlands has tried to revive the dream with a new design for a superconducting circuit.

While Josephson junctions consist of two layers of superconductor sandwiching an insulating layer, the new transistor replaces the insulator with a thin layer of gold. Its speed, like that of the Josephson junctions of the 1970s and '80s, still falls short of the best conventional devices. But the novel design, which the researchers describe in a paper to be published in *Applied Physics Letters*, gives it a key advantage over Josephson junctions: It can not only act as an on-off switch, but can also perform the other function of normal transistors—amplifying an incoming current. "The combination of the known physics and the potential technical application is new," says Gerd Schön of Karlsruhe University in Germany. "It's nice work," adds Michel Devoret of France's Atomic Energy Commission at Saclay, noting that any transistor that can function at extremely low temperatures also has the advantage of low inherent noise.

Josephson junctions allow electrons to "tunnel" through the insulating layer from one superconductor—usually a metallic, low-temperature superconducting material—to the other. The electrons, which are bound together in pairs in the superconductor, can tunnel through the insulator as a weak zero-voltage supercurrent and as a single-electron current. The single-electron current, however, flows only when a voltage is applied across the junction that is strong enough to break apart the electron pairs for their passage through the insulator. When the voltage is reduced below this critical level, the single-electron current is switched off.

In the Groningen device, the insulating layer is replaced by a thin gold layer 0.1 micrometer wide. Electrons do not need to tunnel in the new device; they are simply conducted through the gold layer. The electron pairs are still split up, but the electrons remain "correlated," says Teun Klapwijk of Groningen University: "They are separated, but they 'remember' each other sufficiently to keep the correlation active." As a result, the supercurrent is resurrected at the far side of the gold barrier.



Golden gate. A thin layer of gold regulates the flow of supercurrent in the new circuit.

What controls the supercurrent across the device is a conventional current that flows perpendicularly through the gold layer. Because it is so thin, the gold layer behaves as a structure called a "quantum well." In a quantum well, electrons are confined in a layer so narrow that it affects their quantum-mechanical properties, forcing them to reside only in specific energy levels. When a small current flows along the gold layer, it "heats" the electrons, which fill up many of the available energy levels and impede the current through the superconductors. "This is why we call it a 'hot-electron' tunable supercurrent," says Klapwijk. The effect can shut off the supercurrent entirely, allowing the circuit to act as a switch. But the supercurrent can also be modulated by regulating the current flow through the gold, says Klapwijk, allowing the device to act as an amplifier. So far, the team has achieved a modest voltage gain, of about 2.

To make the device usable as a transistor, says team member Alberto Morpurgo, "the circuit has to be optimized and studied in detail." Even so, Konstantin Likharev of the State University of New York, Stony Brook, thinks the device is unlikely to be practical. Likharev, who is pursuing his own approach to superconducting electronics based on Josephson junctions, says that in order to make these circuits competitive, "you should provide enormous speed advantages. I don't see it here." The Groningen researchers estimate that the switching speed of their superconducting device is about 10 picoseconds. They hope to improve that figure, but so far, says Likharev, the device is slower than the fastest semiconductor devices.

Although the new junctions may not see use as transistors anytime soon, their tunability could increase the versatility of ultrasensitive magnetic detectors called SQUIDS, which consist of Josephson junctions incorporated in loops of superconductor. The group is also studying the possibility of using the junctions as amplifiers in superconducting infrared detectors for astronomical telescopes. Explains Klapwijk: "These devices may have a higher sensitivity and speed compared to the currently used gallium-arsenide amplifiers."

–Alexander Hellemans

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