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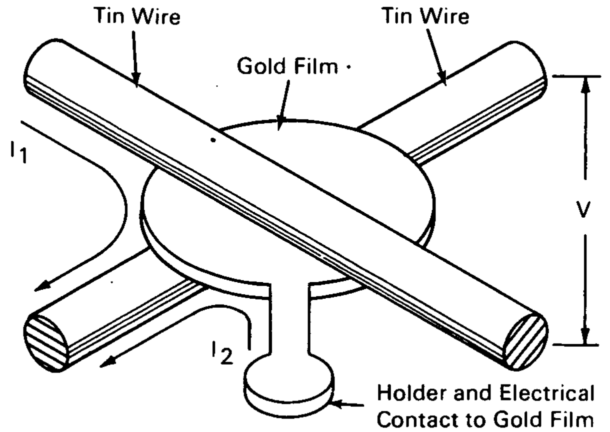
NASA TECH BRIEF

Superconducting "Transistor" Acts as High-Speed Switch



Perspective View of a Superconducting Transistor

A new effect has been observed in the laboratory. A cryogenic, three-terminal device has yielded current-voltage characteristics similar to those of an ordinary transistor. The device was made from two superconducting tin rods in a crossed-wire geometry, separated by an 1860 Å-thick single crystal of non-superconducting gold.

A new technique for constructing the device has been used. The three elements are pressed together by externally controlled mechanical pressure, only after they have been cooled to cryogenic temperatures. Major advantages of this technique over those which involve grown junctions are that no intermetallic diffusion occurs at the junction, and that separate preparation of the three elements, in order to produce clean surfaces and accurately known film thicknesses, is much easier. A much longer electronic mean free path is thus obtained and undesirable effects caused by wide, inhomogeneous transition zones between the different metals are eliminated.

The gold film used in the device is grown separately, by vapor deposition on a highly polished crystal of sodium chloride, which is subsequently dissolved in distilled water. The film is supported on a small loop of copper wire, lifted from the water, rinsed, and dried. The two tin rods are electropolished to remove dirt and oxides, and to provide as smooth a surface as possible. Leads are then connected to the three elements (contact to the gold film is made through the copper loop). The two tin rods are mounted in special holders, with one rod fixed and the other clamped to a spring-loaded mechanism which is remotely adjustable, and which is initially set so that the two tin rods are separated. The gold film is mounted on a remotely adjustable, spring-loaded jack screw and suspended over the fixed rod. The whole assembly is mounted in a cryostat, which is evacuated and cooled to 4.2°K by liquid helium. Then the springs are released, forming the electrical contacts between the gold film and the tin rods.

The device, a perspective view of which is shown in the figure, is then cooled to a temperature of 1.873°K, below the transition point of tin. The magnetic field in the vicinity of the device is reduced to less than 0.1 gauss by magnetic shielding.

Current I_1, corresponding to the emitter current of a normal transistor, is coupled from an external source into one tin rod, through the gold film, and out via the other rod. A second external source supplies current I_2, corresponding to the base current of a normal transistor, to the gold film. I_2 is also output through the second tin rod. Voltage V, corresponding to the collector-to-emitter voltage of a normal transistor, is measured between the two rods. Current I_1 is recorded as a function of V and I_2, yielding the characteristic transistor curves.

(continued overleaf)

Notes:

1. It should be observed that, at its current state of development, the superconducting transistor is a laboratory phenomenon only. However, further work may lead to the development of practical applications, including circuits which achieve extremely fast switching times. Such devices should be of considerable use in computer and microwave applications.
2. Requests for further information may be directed to:

   Technology Utilization Officer
   Headquarters
   National Aeronautics
   and Space Administration
   Washington, D.C. 20546
   Reference: TSP70-10082

Patent status:

No patent action is contemplated by NASA.

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