NASA TECH BRIEF

Multiport Semiconductor Devices

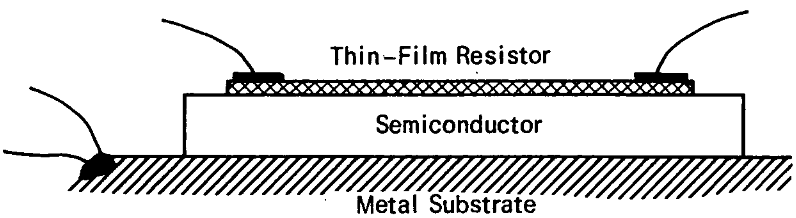

Figure 1. Switching Diode Element; Schematic

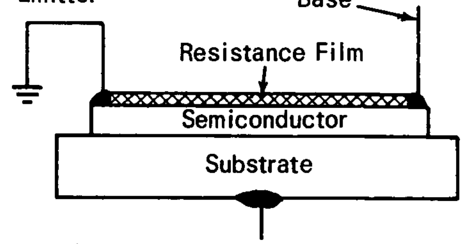

Figure 2. The Terminals Connected to a Transistor Curve Tracer

The problem:

Design of devices, made of semiconductors, incorporating three or more terminals—multiport devices that transform the signal applied to the input port into a suitable output signal. Semiconductor diodes are limited to applications calling for two-terminal or one-port devices.

The solution:

A novel device, made of a variety of semiconductors, including amorphous materials, incorporating three or more terminals. Between at least two terminals, switching action occurs such as in the double-injection diode or in the "Ovonic" threshold switch. The other terminal pair may perform either another switching function or a control function. The control function arises from either an electric-field effect or a thermal effect or both.

How it's done:

For concreteness, assume that the switching diode element (Fig. 1) is a double-injection diode. The top contact is a thin resistive metal film with two terminals between which a potential can be applied. Biasing the diode, below but close to the threshold voltage, puts the diode in the high-resistance state. If a current now passes between the two terminals of the top contact, heat generated adjacent to the active region of the diode lowers the threshold voltage, permitting the device to switch to the low-resistance state.

Very small amounts of power suffice to heat the extremely small volume and cause the switching. In fact, a small amount of control power can switch a greater amount of power. Thus the device provides power gain with the control current applied to a terminal other than that of the current being controlled.

The basic concept can be broadened considerably. For example, the device may incorporate more than one thermally active element; one heater may trigger several switching devices; or two or more switching elements could be in such close proximity that they could trigger each other.

The concept is not limited to crystalline semiconductor devices or metallic resistive elements; basically

(continued overleaf)

it encompasses all semiconductor switching devices, including amorphous semiconductor components in which threshold voltage is temperature-dependent, and where any thermal element can be incorporated for controlling the threshold voltage.

Moreover, the concept covers devices that return spontaneously to the low-conductance state when voltage is removed, as well as memory-type devices. For the latter, the proper thermal cycling for switching of the device from the low- to the high-conductance state could be independent of the conductance-sensing operation; thus flexibility in design of memory systems would be greatly extended.

The validity of the basic concept has been verified with an experimental device (Fig. 2) resembling that shown in Figure 1. One end of the heater was grounded, the other was biased negatively with successively greater values of bias current, and the current-voltage behavior (between the back contact and ground) was plotted for each value of bias current. Although tentative, these results demonstrate that the structures described are readily reduced to practice.

Notes:

1. This innovation may be useful for computer-logic or memory applications; it may interest designers or manufacturers of semiconductor devices.
2. Requests for further information may be directed to:

   Technology Utilization Officer
   Headquarters
   National Aeronautics
   and Space Administration
   Washington, D.C. 20546
   Reference: TSP70-10448

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to:

Patent Counsel
Mail Code 200-11A
Ames Research Center
Moffett Field, California 94035

Source: W. Rindner and F. R. Holmstrom of
Electronics Research Center
(ERC-10293)