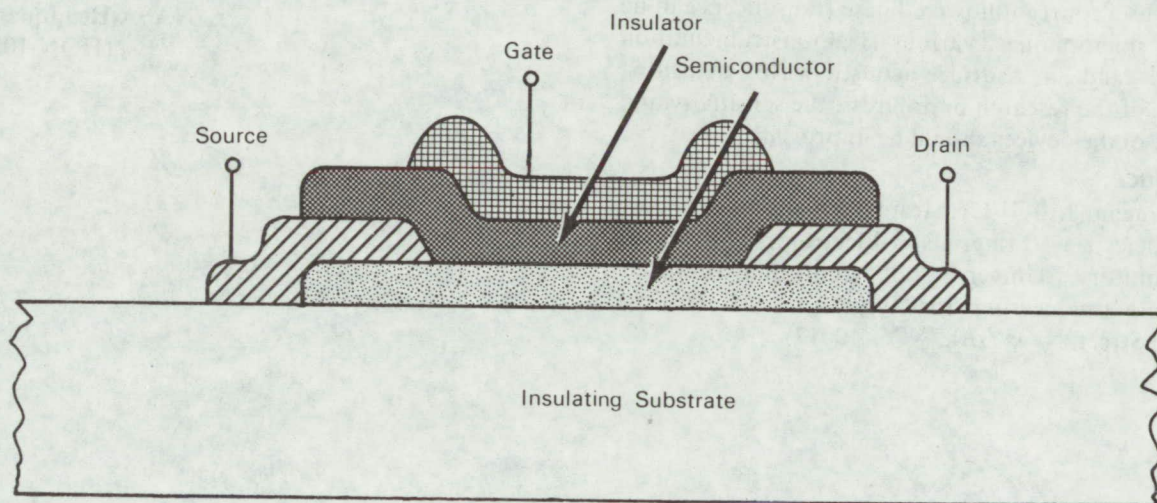


NASA TECH BRIEF



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Piezoelectric Transducer



Typical Thin-Film IGFET Structure

A piezoelectric transducer consisting of a hybrid thin film and a piezoelectric transistor that acts as a stress-sensitive device with built-in gain has been designed. This innovation is novel in that it provides a stress/strain transducer that incorporates a signal amplification stage and sensor in a single package.

Most transducers made with piezoelectric materials require external amplification and do not produce a dc response to an applied strain. By the proper use of piezoelectric materials in the fabrication of an insulated-gate field-effect transistor (IGFET), however, a strain transducer can be constructed that performs both the strain-sensing and amplification functions in one integral device. The advantages of such a device include both fast response to an applied strain and a small, well defined sensing area. In addition, a device using a piezoelectric semiconductor will give a dc response to an applied strain.

Three basic IGFET configurations can be fabricated with piezoelectric materials. These structures involve the use of piezoelectric materials as either the semiconductor, the substrate, or the insulator. The first two of these uses are the most practical at the present time.

The accumulation-mode device in which ohmic contact is made to the semiconductor lends itself to fabrication by thin-film techniques on various substrate materials (Ref.). A cross section of a typical thin-film device is shown in the figure. The substrate can be any insulating material, from a rigid material such as glass to a highly flexible polyimide film. Vacuum-deposited semiconductor materials that have been used in IGFET construction include cadmium sulfide, cadmium selenide, and tellurium. The semiconductor films range in thickness from 100 Å to 1 micron. The silicon-monoxide insulating layer is

(continued overleaf)

typically 500 Å thick, and aluminum is usually used as the electrode material. During a study, devices were fabricated in which the separation between the source and drain electrodes was 0.001 in., while the width of the electrodes was 0.1 in.

Small-area strain transducers can be made by using piezoelectric materials in the construction of IGFET's. Typical transducers have a stress-sensing area of 100 sq mils or less, and can detect strains in the range of 10^{-5} to 10^{-3} . Although these devices could have response times of about 10 nsec, they are presently limited to 1-μ-sec for the larger area devices. The thin-film IGFET strain transducer, which can be deposited on a larger variety of substrate materials, can be used either as a source of current or voltage by the additional deposition of a load resistor using a second IGFET as a source follower. These transducers can be used in microphones, various strain-instrumentation systems, and as surface-acoustic-wave detectors. Because of the research in progress, the sensitivity and stability of the devices should be improved.

Reference:

Conragan, J.: IGFET Strain Transducers Utilizing Piezoelectric Materials, Electronics Research Laboratory, University of California, Berkeley (Audio Engineering Society, Room 428, 60 East 42nd Street, New York, N.Y. 10017).

Note:

This innovation should be of interest to manufacturers engaged in the fabrication of such devices as microphones, hydrophones, and seismographic instruments. It should also be of interest to the designers and producers of thin-film semiconductor devices.

Patent status:

Title to this invention has been waived under the provisions of the National Aeronautics and Space Act [42 U.S.C. 2457 (f)], to the Regents of the University of California, 2200 University Avenue, Berkeley, California 94720

Source: James Conragan and Richard S. Muller of
The University of California
under contract to
NASA Headquarters
(HQN-10548)