# NEW DIMENSIONS FOR INTEGRATED SENSORS

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Integrated Sensor is a designation that invites comparison with the term Integrated Circuit. As is the case with ICs, integrated sensors should be considered as new components that open wholly new dimensions for system design.

Integrated sensors became a reality in the 1960s with the exploitation of the sensitivities of silicon to radiation (electromagnetic as well as nuclear), and to inputs such as temperature, magnetic field, and stress. A considerable maturity has been reached in design for these inputs.

Silicon Hall-effect sensors are well developed and accurate, but they are generally rather large devices which operate well in magnetic fields greater than 100 gauss. Magnetic detectors with sensitivities below one gauss can be attained with carrier-domain magnetometers (CDMs). In integrated sensors these elements can be incorporated with components such as current mirrors, differential comparators, or Schmitt triggers to provide new modes for detection and signal processing. The magnetic signal can be represented as a differential current, a differential voltage, or as a modulated frequency. Because of their high sensitivity CDMs are responsive to the magnetic fields of relatively small currents, and can therefore be calibrated by "on-chip" circuitry.

Despite compatibility problems with conventional IC processing, anisotropic etching of silicon has been employed frequently for micromechanics, an important technology for integrated sensors. Anisotropic etchants are, however, not necessary to make free-standing polycrystalline silicon structures which can be formed by removing the supporting oxide layers with standard HF etching [2]. Doubly supported beams formed of polysilicon have been incorporated into a vapor sensor that detects a small loading change when xylene is absorbed by a polymeric coating on a polycrystalline silicon beam. A complete discussion of this sensor will be given elsewhere, but research on it has given indication of the durability of polysilicon as a material for micromechanics. In the vibrating beam, there is no change in properties after more than $10^{10}$ flexures [3]. Young's modulus for polycrystalline silicon has been obtained through experiments with this micromechanical structure, and the stress at the interface between polycrystalline silicon and silicon dioxide has been studied [4].

Piezoelectricity in thin films deposited on silicon ICs provides an alternative to piezoresistance in silicon for stress sensing. Sputtered ZnO films have been shown to be suitable for this purpose, and have been combined with micromechanics to produce a high-performance accelerometer [5]. Sputtered ZnO has also been used as a pyroelectric with applications to mass air-flow sensing [6].

Finally, silicon technology combined with sputtered ZnO films also makes possible surface-acoustic-wave integrated sensors for vapor detection. These systems have potentially great sensitivity and flexibility. Especially significant for integrated-sensor design is the finding that acoustic energy can be transferred through plate modes in thinned silicon diaphragms. This provides a means to keep the electronics of the sensing system remote from the interaction surface [7].

Clearly, old and accepted units will be used to measure the integrated-sensor systems that are built by exploiting these new dimensions. The units are simple: success or failure. The odds -- and the state of maturity of today's electronics -- strongly favor success.

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