MICROSYSTEMS WITH INTEGRATED CAPACITIVE, MAGNETIC AND OPTICAL SENSORS

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Key words: integrated sensors, Hall sensors, optical sensors, capacitive sensors

Abstract: This article discusses microsystems with integrated sensors for measuring various physical values like acceleration, electrical current and motion. An integrated microsystem is presented for all three physical values. These microsystems are composed from the integrated sensor and the processing electronics all on the same silicon die. The emphasis of this article is on the presentation of the integrated sensors.

Mikrosistemi z integriranimi kapacitivnimi, magnetnimi in optičnimi senzorji

Ključne besede: integrirani senzorji, Hall senzorji, optični senzorji, kapacitivni senzorji

Izvleček: Članek obravnava mikrosisteme z integriranimi senzorji za merjenje fizikalnih veličin kot so pospešek, električni tok in gibanje. Za vsako veličino je predstavljen integrirani mikrosistem, ki je sestavljen iz senzorjev in obdelovalne elektronike, ki sta integrirani na istem silicijevem substratu. Poudarek članka je na predstavitvi integriranih senzorjev.

1. INTRODUCTION

We are witnessing an extreme advent in the computer and communication technology. In contrast to these advances the possibility to gather and process information from the physical world lags behind. Great advances in this area are possible with the development of integrated microsystems. These are physical value measuring systems which combine the sensor and the processing electronics on the same silicon die.

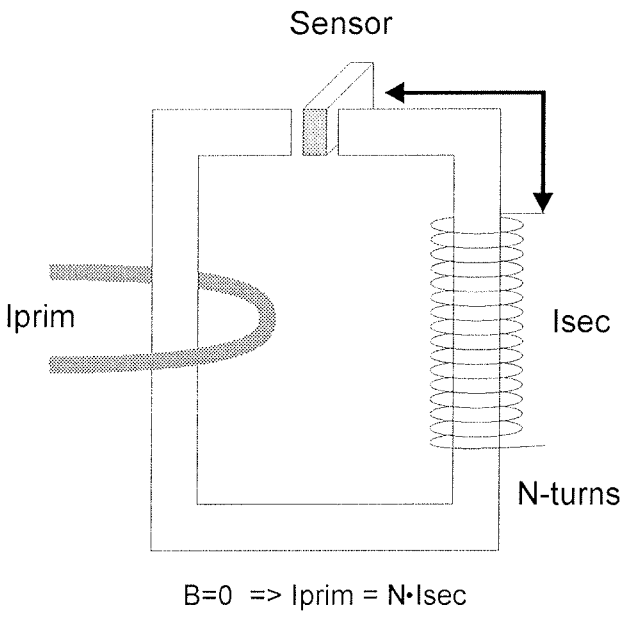

Fig. 1: Closed loop current measuring system

Three various microsystems are presented in this article:

- magnetic microsystem with integrated Hall sensors for electrical current measurement
- capacitive microsystems with micromechanical sensor for acceleration measurement
- optical microsystem with integrated photo diodes for displacement measurement

All three microsystems can replace the traditional discrete sensor and electronics systems and therefore reduce the cost and the area of the measurement system.

2.1 Magnetic microsystem with integrated hall sensors

The Hall magnetic sensors are compatible with the standard CMOS process therefore they can be easily integrated with the use of the n- well layer. The inherent characteristic of the Hall sensor can be largely improved with various techniques as the current spinning, bias current compensation, use of spatially distributed Hall sensors etc.

In the presented system a Hall sensor array is used for measuring the electrical current through the primary coil. This current generates a magnetic field sensed by the microsystem which also drives the secondary coil. The system is in a closed loop configuration and therefore the microsystem with the use of the secondary coil zeroes the magnetic field in the core. The current through the secondary coil is proportional to the primary current. The advantage of the closed loop system is the galvanic separation and high bandwidth (200kHz) of such a system.

An example of such a system is on fig.1. The magnetic sensors, processing electronics and the current driver amplifiers are all on the same silicon die (fig.2).

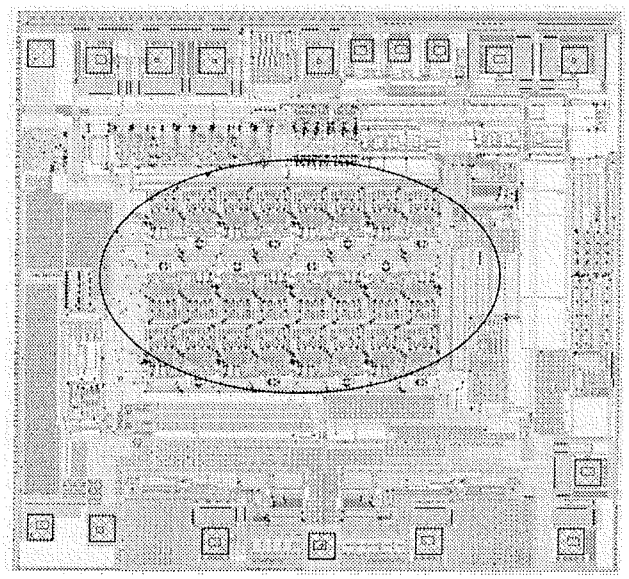

Fig. 2: Die plot with the marked magnetic sensor array

2.2 Capacitive microsystem for acceleration measurement

Various micromechanical objects can be created with the use of micromachining. A moving polysilicon plate can be constructed by underetching. This plate can bend under various forces enabling us to sense mechanical forces on the plate. A capacitor can be constructed using this polysilicon plate. If the system is accelerated the plate bends and therefore the capacitance also changes. A closed loop principle was used in the presented microsystem. A sensing capacitor plate and a actuator plate is needed for that. The actuator plate compensates the mechanical forces on the plate. The sensitivity of such a sensor is only 10aF/g therefore special care must be taken when designing the processing electronics. The resulting output sensitivity of the system is 40mV/g with a SNR of 60dB. On fig. 3 the cross-section through the microsystem is visible, on fig. 4 the layout of the IC with the sensing and actuating plate is visible.

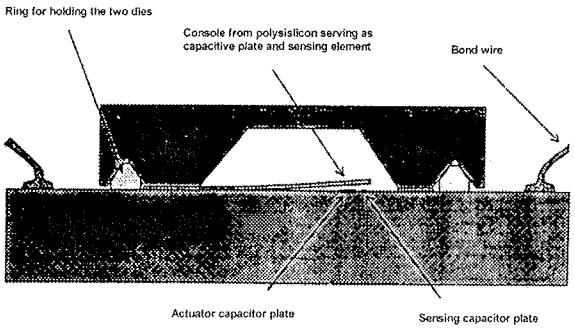

Fig. 3: Capacitive microsystem cross-section

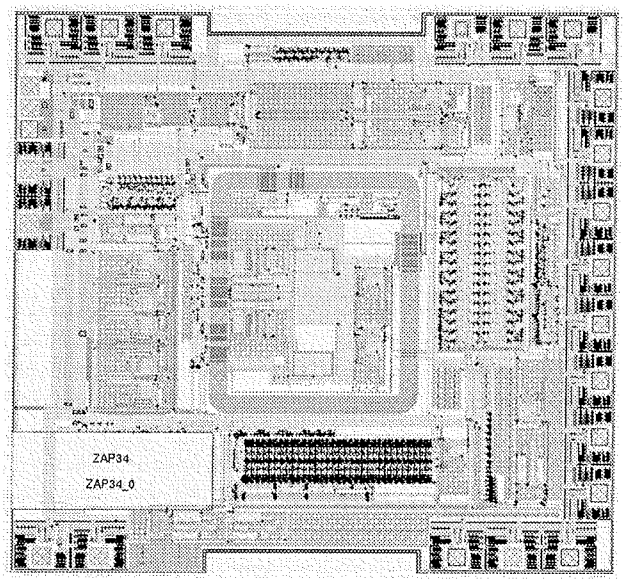

Fig. 4: Layout of the capacitive microsystem

2.3 Optical microsystem for displacement measurement

Such a microsystem combines the integrated photo diodes with the analog front-end and an interpolator for generating digital pulses from the analog information.

The photo diodes are combined into an optical array which senses the light filtered by the code wheel. By sensing the light the displacement of the wheel can be sensed. The integrated electronics amplifies the diode signals and with the use of the interpolator two orthogonal digital incremental output pulses are generated, representing the motion of the wheel.

The schematic of such a microsystem is on fig. 5, the layout of the IC with the photo-diodes and electronics is on fig. 6. The achieved photodiode responsitivity is 0.52A/W, the on chip interpolator division factor is 40.

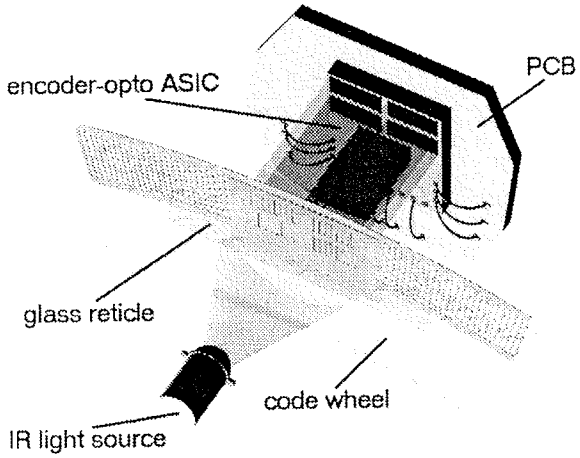

Fig. 5: Optical microsystem for incremental position application

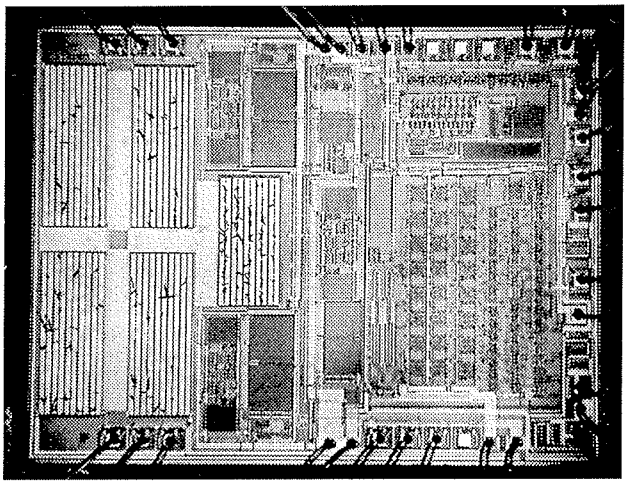

Fig. 6: Optical microsystem IC die plot with the photodiodes on the left side

3. CONCLUSION

Various sensors can be integrated in the standard CMOS technology enabling the development of integrated microsystems. With these sensors various physical values can be measured directly or indirectly.

4. LITERATURE

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