

# Capacitive Inclination Sensor

## High Performance Using MID Technology

At HSG-IMAT, a low cost micromechanical capacitive inclination sensor based on MID-technology (Molded Interconnect Device) is developed. The three dimensional polymer devices are fabricated by injection molding and covered by a structured metal layer using electroless plating and laser ablation. The sensor device shows very promising properties, like a linear characteristic and a resolution of about 0,01°. The reliability of the sensor was proved within thermal shock test and constant damp heat storage.

The principle of operation of the sensor concept shown in Fig. 1 is based upon a differential capacitor arrangement, formed by the electrodes 1a, 1b and 2. The electrodes are fabricated on opposite front ends of a cylindrical cavity which is half filled by a dielectric fluid. In horizontal position both capacitances are equal. If inclination of the device occurs, the fluid keeps its horizontal position. Therefore the capacitances change inversely. The emerging differential capacitance is converted to an analogous voltage by an ASIC.

Fig. 2 shows the two MID-parts of the sensor fabricated by semi-additive laser patterning. After bonding both MID-parts by an adhesive the cavity is filled with the dielectric fluid. Afterwards the device is mounted on the PCB with electrical readout by an isotropic conductive adhesive as shown in Fig. 3.

As indicated in Fig. 4, the sensor shows a accuracy better than 0,4° within ±80°. The resolution of the sensor is about 0,01° and shows a high repeatability. The temperature dependence is very low and almost linear. At dynamical inclination, a hysteresis, which is proportional to the rotational speed, occurs.

To show the reliability of the sensor thermal shock test and constant damp heat storage test were performed.

### Fabrication process

- Micro injection molding of polymer parts from LCP
- Electroless plating of Cu
- Laser patterning of Cu layer
- Electroless plating of Ni-P and Au
- adhesive bonding of MID-parts
- Dispensing of dielectric fluid
- SM assembly of sensor by ICA

### Sensor Features

- Dimension: 13,0 x 15,4 x 2,8 mm<sup>3</sup>
- Resolution: 0,01°
- Overall accuracy ±80°: 0,39°
- Temperature range: -40 / 85°C
- Temperature range: -40 / 125°C in preparation
- Temperature coefficient: 0,01°/K
- 360° capacity in preparation

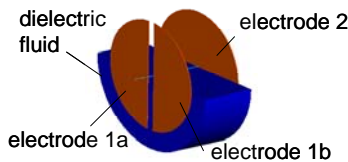


Fig. 1: Principle of operation

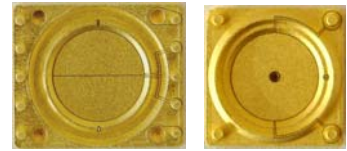


Fig. 2: MID-parts of the sensor



Fig. 3: MID-sensor on PCB

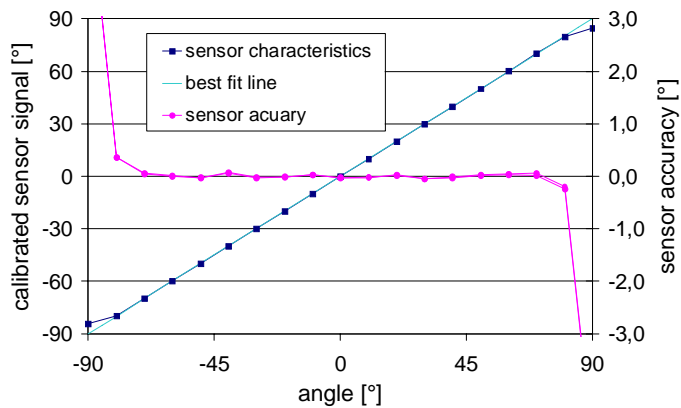


Fig. 4: Characteristic and accuracy of the capacitive inclination sensor

After 1000 thermal shock cycles of 30 MID-sensors at temperatures from -40°C up to 85°C no sensor failed. Also the sensors withstand 1000 hours constant damp heat at 85°C / 85% relative humidity. Actually sensors with extended meas-

urement range of 360° and extended temperature range up to 125°C are developed. Further work is done in optimisation for a fully automated fabrication and assembly processes.