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# **Silicon Capacitive Accelerometers and Applications**

## 硅电容加速度传感器和应用

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Application Support  
VTI TECHNOLOGIES

# VTI Technologies

## 公司简介

A world leader in the design and production of inertial sensors with wide expertise in motion measurement.

- ◆ High capacity factory dedicated to micromechanics
- ◆ Advanced clean rooms and equipment

是全球设计和生产硅电容惯性传感器的先驱，  
在运动测量方面有着广泛的业能力

- ◆ 致力于微器械加工的高产量生产
- ◆ 先进的清洁生产厂房和设备



# Global Forerunner in MEMS Sensors

## MEMS传感器的全球先驱

- ◆ Experience data base from more than 20 years
- ◆ Head office in Finland
- ◆ Assembly plant in Mexico
- ◆ Sales 60M€, 600 employees
- ◆ 20多年的数据库
- ◆ 总部在芬兰
- ◆ 组装在墨西哥
- ◆ 年销售6千万欧元，6百员工



# Global Forerunner in MEMS Sensors

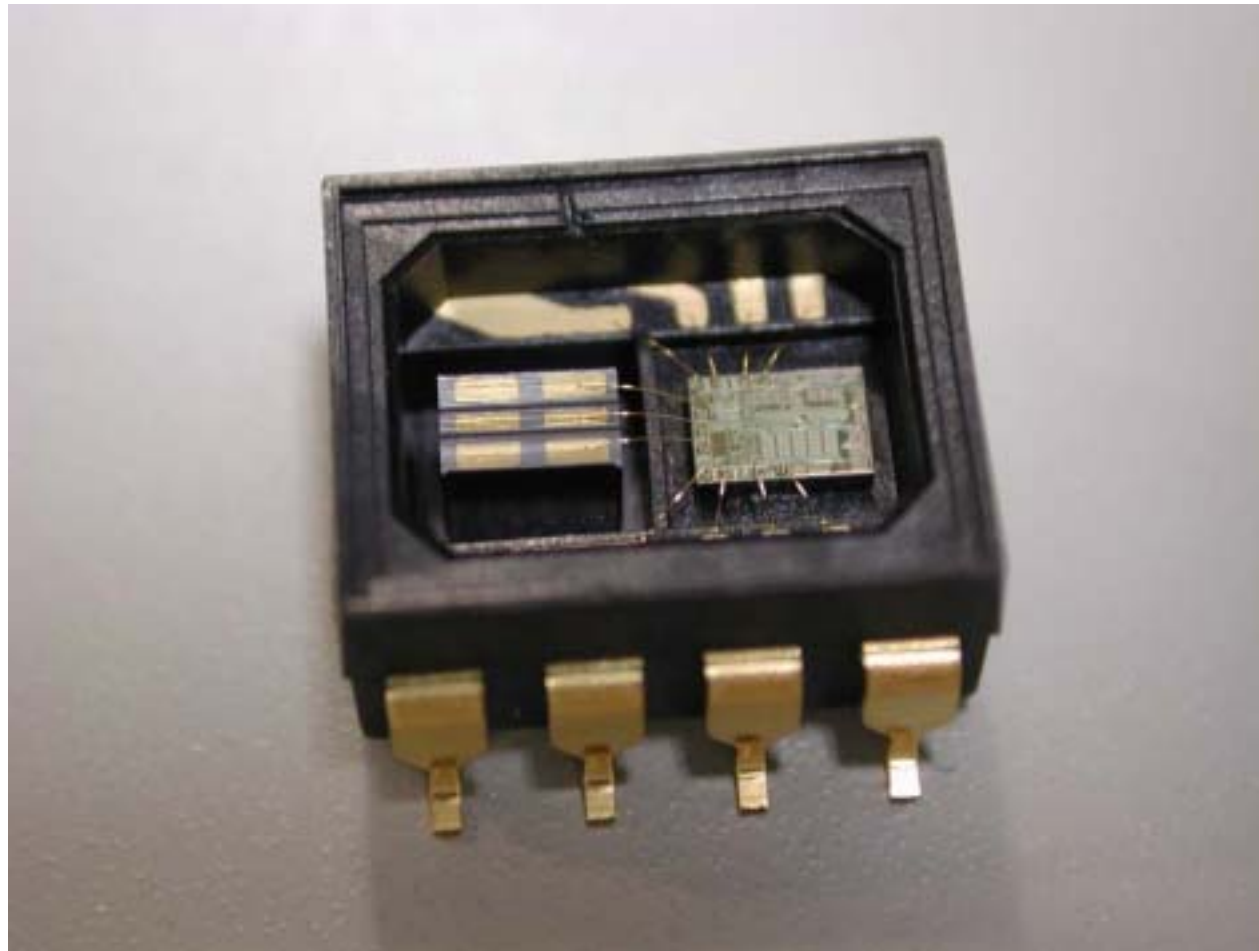
## MEMS传感器的全球先驱

- ◆ Product range from sensor elements to complete stand alone sensors
- ◆ Customers: Global OEMs & automotive system suppliers > 90% of sales 2003
- ◆ Market leader in low-g accelerometers in the automotive industry
- ◆ 产品包括敏感元件到完整传感器
- ◆ 顾客：全球OEM和汽车系统供应商> 95% 2003年销售额
- ◆ 在汽车工业中低g加速度传感器的先驱



## The Structure of the Sensor 传感器的结构

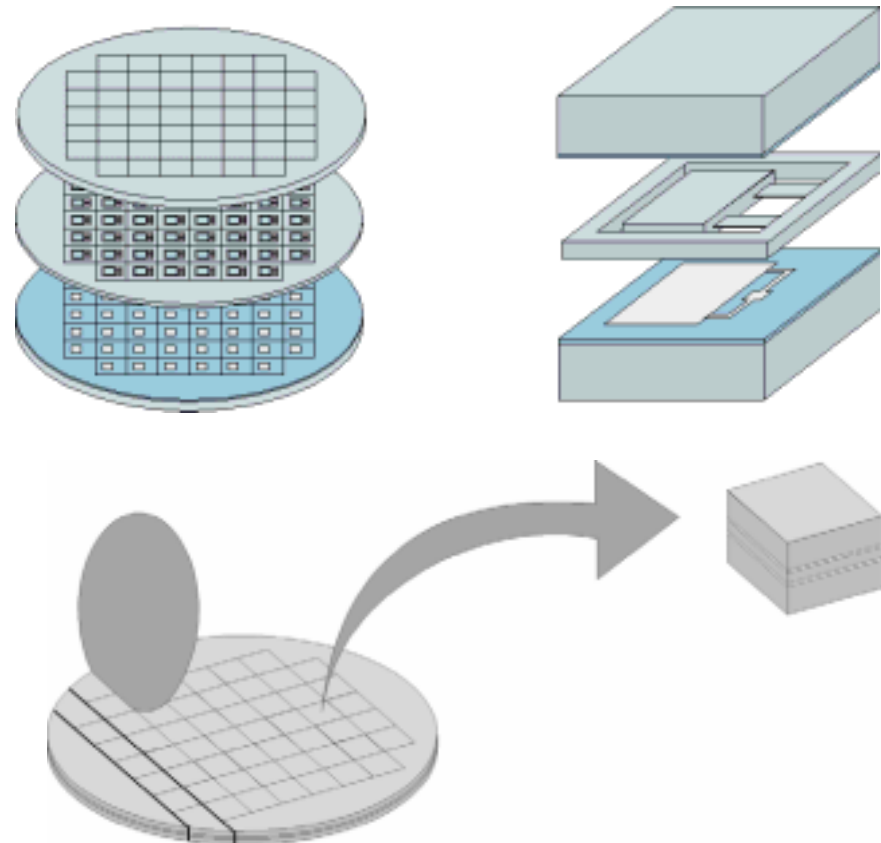
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# Silicon Capacitive Accelerometers

## 硅电容加速度传感器

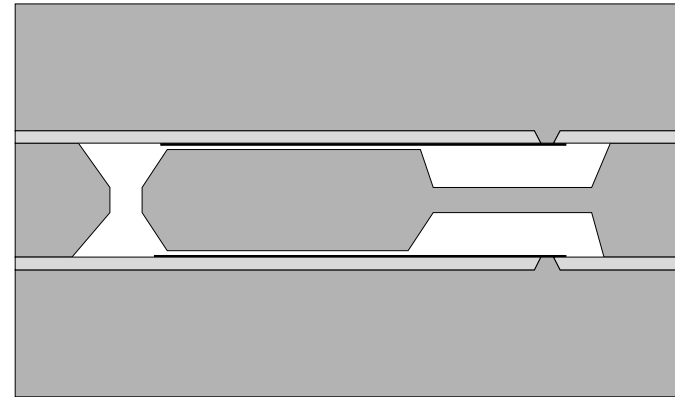
- ◆ The sensing element consists of three layers of silicon
- ◆ Capacitors one on each side of the proof mass
- ◆ Glass insulation between the electrodes
- ◆ 传感元件由三层硅片构成
- ◆ 在测试片两边形成电容
- ◆ 两级之间玻璃绝缘



# Silicon Capacitive Accelerometers

## 硅电容加速度传感器

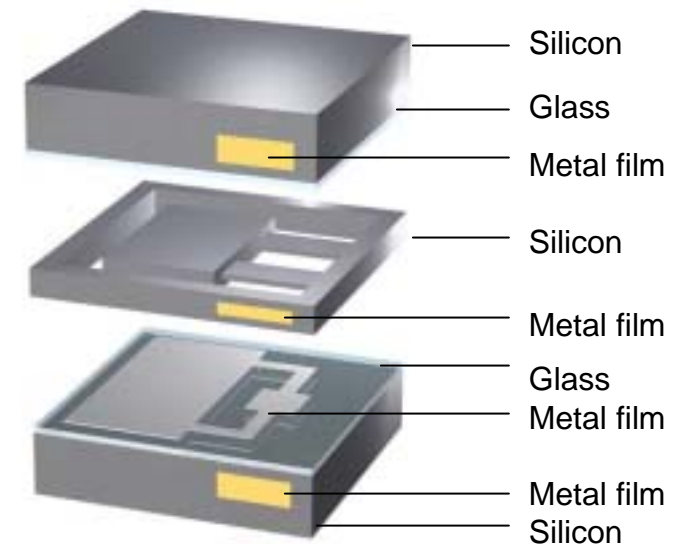
- ◆ Symmetrical structure
- ◆ Gas damping in the hermetically sealed cavity
- ◆ Proof mass and springs in the mid wafer
- ◆ 对称结构
- ◆ 密封洞穴中的气体阻尼
- ◆ 在硅片中的测试片和弹簧



# VTI's Silicon Capacitive Sensor Technology

## VTI的硅电容传感器技术

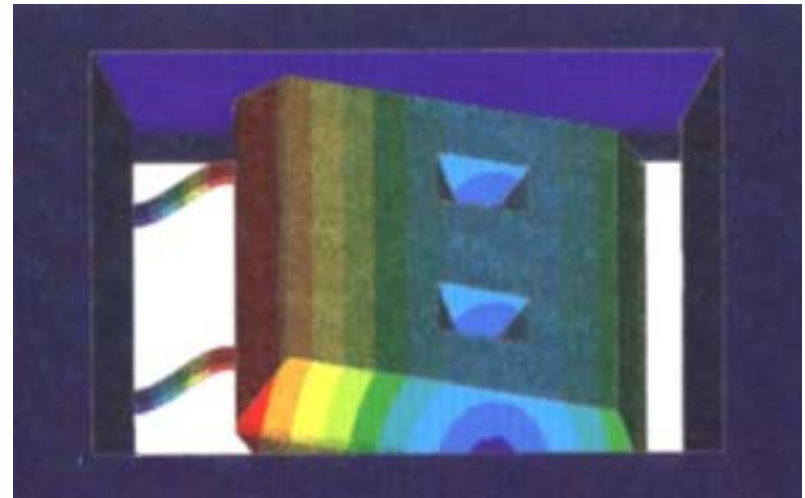
- ◆ Silicon bulk micromachined capacitive sensors
  - Hermetically sealed structures
  - No particles or chemicals can get into the element
  - Customised sensors
- ◆ 体内微机械加工的硅电容传感器
- ◆ 对称结构
- ◆ 密封洞穴中的气体阻尼
- ◆ 在硅片中的测试片和弹簧



# VTI's Silicon Capacitive Sensor Technology

## VTI的硅电容传感器技术

- ◆ Technology for producing high performance acceleration sensors
- ◆ Ideal elastic material: no plastic deformation, tough up to 70 000 g for 1 g sensor
  - Single crystal silicon
- ◆ 生产高性能的加速度传感器
- ◆ 理想的弹性材料：没有弹性变形，1 g传感器能达到70 000 g的强度
  - 单晶硅



# Why This Technology

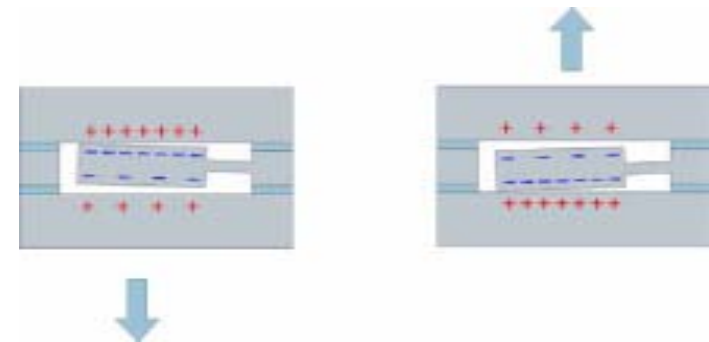
## 为什么用此技术

### ◆ Capacitive Sensing

- Direct measurement of deflection
- Based on the variation of a gap between two planar surfaces
- The capacitance or charge storage capacity of a pair of plates depends on a gap width and plate area A:  $C = \epsilon_0 * A/d$

### ◆ 电容传感

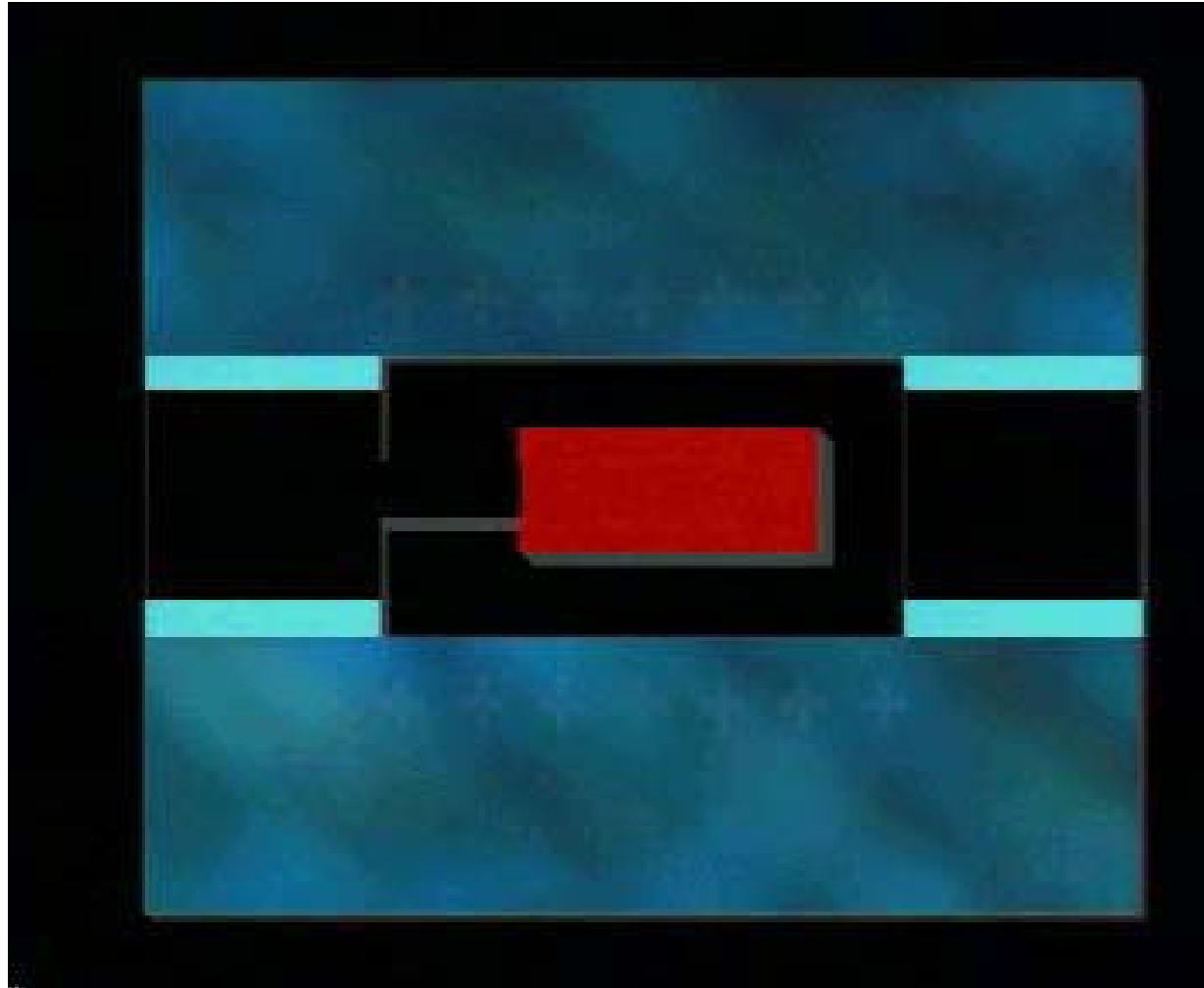
- 直接测量变形
- 基于两平板间的距离变化
- 两极间的电容取决于距宽和板面积A:
- $C = \epsilon_0 * A/d$



# VTI's Sensing Element Operation

## VTI传感元件的工作原理

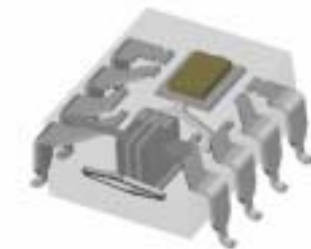
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# Why This Technology

## 为什么用此技术

- ◆ Symmetrical Structures
  - Improved accelerometer zero stability, linearity and cross-axis sensitivity
    - ◆ Temperature dependence less than 1 mg/°C
    - ◆ Non-linearity typically below 1%
    - ◆ Cross-axis sensitivity typically less than 3%
  
- ◆ 对称结构
  - 提高了传感器的零点稳定性，线性度和十字轴灵敏度
    - 温度漂移小于 1 mg/0C
    - 非线性性小于 1 %
    - 十字轴灵敏度通常小于 3 %



# Automotive Applications

## 汽车工业中的应用

- ◆ Antilock Braking (ABS)
- ◆ Traction Control Systems (TCS)
- ◆ Vehicle Dynamics Control (VDC)
- ◆ Electronical Stability Program (ESP)
  - ◆ 防抱私制动系统
  - ◆ 牵引控制系统
  - ◆ 车辆动力控制
  - ◆ 电子稳定系统



# Automotive Applications

## 汽车工业中的应用

- ◆ Electronically Controlled Suspension (ECS)
- ◆ Electric Parking Brake (EPB)
- ◆ Tyre Pressure Monitoring System (TPMS)

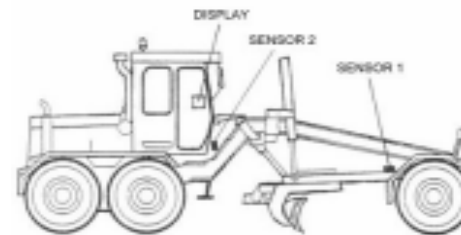
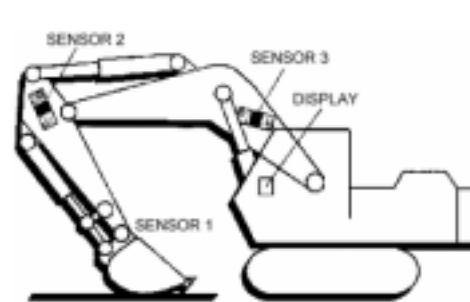
电子控制缓动装置  
电子停车制动  
轮胎气压控制系统



# Industrial Applications

## 其它工业领域中的应用

- ◆ Vehicle Tilt Monitoring and Control
  - Grader with Inclinometers
- ◆ Digging Depth and Slope Control Motor
  - Inclinometers on an Excavator
- ◆ 车体倾斜检测和控制
  - 斜度仪
- ◆ 挖掘深度和坡度的控制
  - 挖机上的倾角仪



# Industrial Applications

## 其它工业领域中的应用

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- ◆ Train Lateral Force and Vertical Acceleration Monitoring
  - High Speed Train Inclination and Suspension
- ◆ 火车侧面牵引力控制
  - 高速火车的倾斜和制动



# Industrial Applications

## 其它工业领域中的应用

- ◆ Patient Monitoring
- ◆ Seismic Monitoring
- ◆ Platform Levelling
- ◆ Inclinometer Instruments
- ◆ Inertial Navigation
- ◆ Sport & Fitness
- ◆ 病人监护
- ◆ 地震控制
- ◆ 平台水平控制
- ◆ 倾角测量仪器
- ◆ 惯性导航
- ◆ 体育和健身

