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微纳技术与精密机械

自增强承压圆筒结构的超高压力传感器

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摘要： 采用自增强技术与硅压阻效应研制了超高压力传感器，该传感器能够消除封装残余应力的影响并保证其在进行大量程压力测量时具有较高的灵敏度输出。该传感器的弹性元件为圆筒结构的高强度弹簧钢，敏感元件为平膜倒杯式硅压阻芯片。传感器工作时，超高压力作用在圆筒结构的金属弹性元件使其发生轴向位移，该位移量通过弹性元件顶端的传递杆施加到周边固支的硅压阻芯片上，使置于此处的4个电阻条阻值发生线性变化，从而输出与被测压力成正比的电压值。在研究弹性元件在1 000 MPa超高压力下的工作性能时，理论与仿真相结合研究了弹性元件的承载强度，确定采用自增强处理技术提高弹性元件的承载能力。最后，对封装好的传感器静态性能进行了标定实验。实验结果表明，该传感器能够承受1 000 MPa以上的工作压力,线性度为0.52%，满足工业领域的应用需求。

关键词： 超高压力传感器 自增强技术 压阻效应效应 微机电系统 圆筒结构

Ultra-High Pressure Sensor with Autofrettaged Cylinder Structure

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Abstract: An ultra-high pressure sensor based on autofrettage technology and piezoresistive effect is developed to remove the residual stress in packaging and to ensure a high sensitive output in pressure measurement with a large range. The elastic element is made of high strength spring steel with cylinder structure, and the sensitive element is silicon flat chip with an inverted cup structure. When the pressure is applied to the metal elastic element, the axial deformation of the metal elastic element is occurred and passed to the chip via a pass rod, then the chip's resistive signal is proportional to the axial deformation based on the piezoresistive effect. The pressure measurement is accomplished by measuring the resistive signal. In the study of working ability of the elastic element, the load bearing strength of the elastic element is researched by combining the theory and simulation, and the autofrettage technology is used to improve the loading ability of the elastic element. Finally, the static performance experiments in 250 MPa and 1 000 MPa ranges are carried out for a packaged sensor respectively. The experiments show that the comprehensive accuracy of the sensor is 2.3%, the linearity is 0.7% in 250 MPa and 0.52% in 1 000 MPa . The simulative and experimental results both indicate that the metal elastic element with autofrettaged cylinder structure is able to endure ultra-high pressure beyond 1 000 MPa, and the developed sensor can meet the measuring demand of the contemporary industry.

Keywords: ultra-high pressure sensor autofrettage technology piezoresistive effect Micro-Electro-Mechanical Systems (MEMS) cylinder structure

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