Design of MEMS vibration sensor for harsh environments

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Harsh environments present great challenges for proper sensing operations. These working conditions include extreme (low and high) values of one or more parameters such as radiation, temperature, humidity, vibration pressure, electromagnetic interference (EMI), erosive flows, and shock[1]. Most articles on harsh environments have focused on applications with high temperatures in the range of 600 ^{o}C to 1200 ^{o}C. Oil and gas applications, on the other hand, introduce additional complexities for sensors submerged in oil for long durations. Novel sensing designs are therefore needed to address these challenges.

This paper introduces 2 contributions. First, parylene is proposed as an encapsulation material for chemically active environments[2,3]. It can work continuously at a temperature of 220 ^{o}C. The second contribution is a piezoelectric MEMS vibration sensor design, with parylene encapsulation, for submerged long-duration uses in oil environments. The piezoelectric MEMS vibration sensor takes advantages of a small footprint and a low fabrication cost. The small footprint makes it easier for the protective encapsulation to work effectively. The proposed sensor is designed to work at temperatures of up to 150 ^{o}C with a frequency range of 10 kHz. The sensor is designed with Si as the substrate for a proof mass, a diaphragm design, and AlN as piezoelectric material.

The paper presents the design, analysis, proposed fabrication method, and testing. Simulation results show how a trade-off is made between the resonant frequency and charge output from the piezoelectric material. The experimental results demonstrate the performance of the proposed parylene encapsulation method designed to protect the sensor from harsh environmental conditions, while submerged in oil for long durations.

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[1] Lakal et al., "Sensing Technologies for Condition Monitoring of Oil Pump in Harsh Environment."
[2] Chong et al., "Non-Hermetic Packaging of Biomedical Microsystems from a Materials Perspective."
[3] Zhao et al., "A Packaging Technique of Pressure Sensor for in Vivo Measurement System."

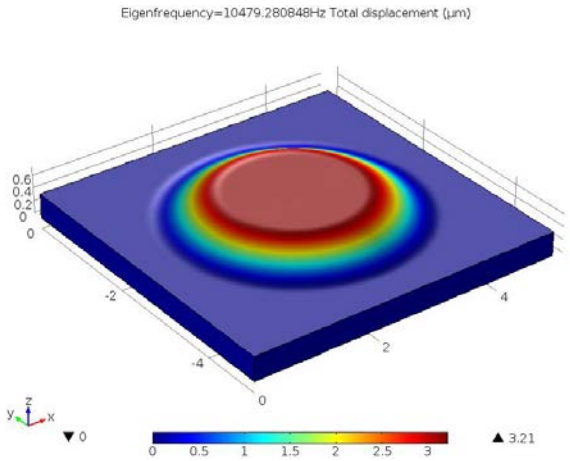

Figure 1. COMSOL analysis results of the proposed MEMS vibration sensor for harsh environment, showing the eigenfrequency for the sensor 10.5 kHz.