Development of Indigenous Micro-gyroscope Technology

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A micro-gyroscope is an inertial sensor that is used to measure an angular-rate or an angle of rotation. Compared to the traditional gyroscopes (sperry gyroscope, ball electrostatic gyroscope, ring laser gyroscope etc.), micro-gyroscopes have many advantages such as low cost, small size, and light weight. As a result, they have attracted a lot of attention in past few years for many applications e.g. automobile, consumer electronics, inertial navigation system etc. This paper discusses the development of indigenous micro-gyroscope technology at CSIR-Central Electronics Engineering Research Institute (CEERI). A total of five structural designs of micro-gyroscope are implemented: symmetrical and decoupled linear micro-gyroscope [1], two-gimbal torsional micro-gyroscope [2], torsional gyroscope having robust drive mode [3], torsional gyroscope having robust sense mode [4], and torsional gyroscope having robust drive and sense modes [5].

The entire development cycle is divided into four activities: modelling, fabrication, packaging, and characterization. The individual micro-gyroscope is modelled mathematically by deriving its equations of motion and then solving these equations in frequency domain to get the sensor behaviour. To fabricate these devices, an SU-8 based UV-LIGA process having Ni/Ni-Fe as the key structural layer is developed. UV-LIGA combines UV lithographic patterning of a thick photoresist and electroforming of a structural material into the patterned photoresist mold. Towards this process development, photolithography to create 11 μm thick molds for electroforming the sacrificial copper and structural Ni/Ni-Fe layers is optimized using multiple exposure technique that ensures near vertical side walls [6]. Also, a 2.45 GHz MW plasma etching process is developed with CF_4+O_2 mixes approaching 10% in order to remove the highly cross-linked SU-8 from high aspect ratio structures without damage or alteration to the electroformed metals. The high residual stress in the electroformed Ni structural layer, which caused bending in the released structure, is minimized by replacing the structural layer from pure Ni to Ni-Fe alloy. This developed process replaces the need for expensive equipment like DRIE, LPCVD etc. with a simple and low-cost electroforming set-up. Next, the fabricated devices need to be vacuum packaged to minimize the effect of air-damping and get the operating voltage below 3.3 V, which is an essential requirement for practical applications. However, to the best of our knowledge, such vacuum packaging facility for MEMS devices does not exist in India. Hence, an indigenous equipment for chip level vacuum packaging of