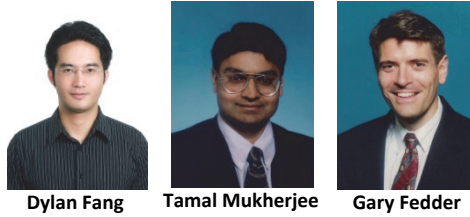


SI-CMOS-MEMS Technology for Inertial Sensors



Chip-scale inertial sensing technologies have received significant attention in recent years for a number of civilian and military applications. In this research, Si-CMOS-MEMS inertial sensors toward high resolution are developed. In order to meet the low noise specification, the proof mass is thickened by including silicon substrate as parts of the device. A chip-scale substrate thinning process is being developed to provide a uniform device thickness of 50 μm . The thinned CMOS chip will then be bonded to a handle substrate using solder bonding with electroplating technology and subjected to front side CMOS release process using advanced oxide etch (AOE) and Si DRIE to create the CMOS-MEMS structures. The silicon is also incorporated in the suspension of devices, which will improve long-term stability. Fig. 1 shows a 5mm x 5mm Si-CMOS-MEMS chip along with a simplified cross section of the process. This chip includes three axis accelerometers, a z-axis gyroscope and two axis magnetometers with all on-chip interface circuitry. Fig. 2(a) and (b) show SEM pictures of released lateral accelerometers. The y-axis accelerometer has a stress release frame to investigate the impact of stress with respect to bias stability. The measured resolution for the accelerometer is 0.25 mg/rt Hz and is currently limited by flicker noise from the on-chip circuitry. Fig. 2(c) and (d) shows a z-axis gyroscope and an x-axis magnetometer. The measured coupling drive resonant frequencies of gyroscope are 11.05 kHz and 11.86 kHz for in-phase and anti-phase modes while driving only in the anti-phase mode. The measured quality factor for the gyroscope is about 593 in ambient. The gyroscope serves as a test structure to gauge the process variations. A model is developed to extract the process variations based on the drive frequency responses of the gyroscope.

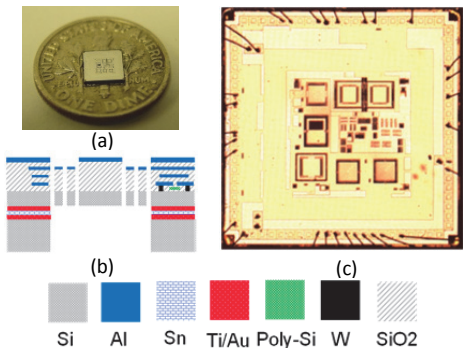


Fig. 1: (a) A Si-CMOS-MEMS chip on a dime (b) Si-CMOS-MEMS process (c) Top views Si-CMOS-MEMS Devices

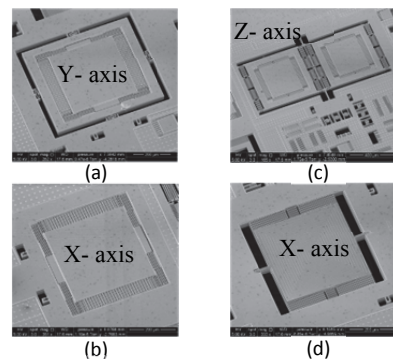


Fig. 2: SEM images of different Si-CMOS-MEMS devices (a) Accelerometers (b) Accelerometers (c) Gyroscope (d) Magnetometer.