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# Genesis of MEMS Accelerometers for Select the Optimal Accelerometer for Bio Applications

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***Abstract: MEMS(Micro Electro Mechanical Systems) Accelerometer is most popular and successful MEMS device for its versatile and multipurpose applications in different fields capable of measuring wide range of parameters ranging from vibration, acceleration, tilt and shock[1]. Accelerometers, individually have their own operation and are also used in conjunction with other devices like gyroscopes, switches to make unique special devices like Inertial Measurement unit, widely used in consumer electronics, giving MEMS Accelerometers the giant share in the whole MEMS market. They have arrived as successful marketed devices in various designs and served many application in the fields of automobile , navigation, bio medical and space applications[2]. These devices have diversified structural design and work on different principles, making them worth a study in terms of classification, selection for suitable application. Having the advantage of being cost effective and of little form factor, these devices have greater scope in various domains where the mechanical movements are needed to be analyzed. There is a huge unexplored area of BIO MEMS into which Accelerometers have to stretch their boundaries making Human body specific applications akin and par the present research. The present paper consolidates the existing accelerometers focusing on their applications while analyzing them in the light of their significance in each field of application. There is a great space for domain specific designing of the accelerometers trending into the usage in the current times.***

***Keywords : MEMS, Accelerometers, IMU, Bio-MEMS.***

## I. INTRODUCTION

The term MEMS (micro electro mechanical system) have changed the measurement world miniaturized and realized at near nano to micro level, made a revolutionary turn in the sensor industry. The small in scale as an entity and large in scale as a production of manufacturing of sensor is made possible from the advancement of semiconductor IC industry process techniques.

The well documented procedural steps with customization facility based on application helps to fabricate novel devices belongs to mechanical, electronic, optical and biological fields. The MEMS technology for micro machining the sensors used in industry for computational and control activities. To talk about the MEMS industry success ,one must start with the MEMS accelerometers and MEMS pressure sensors which had a strong foot trod in achieving market share in Testing and Evaluation ,aero space and automobile industry. The present MEMS industry categories by major sensor domain pressure 40%, Temperature 25%, Accelerometers 13%, Flow 9% and 5% of occupation by force sensors. Every year MEMS market growth if rising by 6%. The present work in this paper provides the brief history of accelerometer since it get commercialized and registered officially since 1936[1]. Earlier without MEMS technology , men who get the credit of making marketable accelerometers are McCollum& Peter, who contributed for the invention of piezo resistive accelerometer, in fig:1, it can be observed the primitive piezo resistive accelerometer model has a registered dimensions as 3/4 ¥ 1-7/8 ¥ 8-1/2 in Size and has twenty to fifty carbon rings inserted into a frame structured in E shape in turn they form half wheatstone bridge.

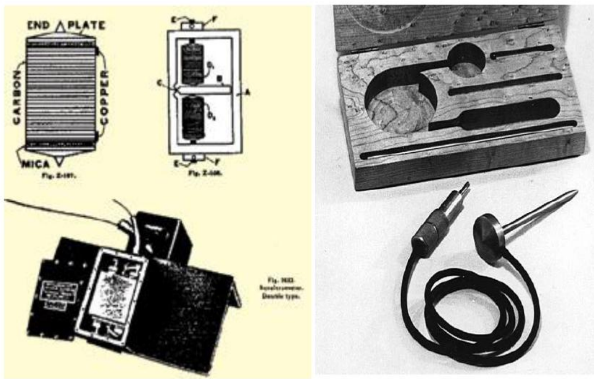


**Figure:1a) premitive piezo resistive accelerometer b) Piezo electric accelerometer**

It is designed for the 2 axis accelerometer with "Cork Damping Adjustment" measures acceleration ranges to 100g. The surprising price of each accelerometer quoted was 420 dollars. In 1938 April 3rd, Arthur Ruge and Edward Simmons both got he credit of discovering strain gage leads to the advent of bonded resistance strain gauge. After the invention of bonded strain gauges few months later , J. Hans Meier constructed an accelerometer with bonded strain gauges at MIT(Massachusetts Institute of Technology) with the specifications of 4 Hz of frequency response and an impact range of 2 h for the water tower earth quake study.

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Later in 1943 Louis Statham of Statham Instrument Company, in Los Angeles, CA has experimented with un bonded strain gauge accelerometer for the dynamic test applications. In 1955, a text booked authored by C. C. Perry and H. R. Lissner named as" The Strain Gage Primer, published by McGraw-Hill, described un bonded accelerometers has high range approx 500g .

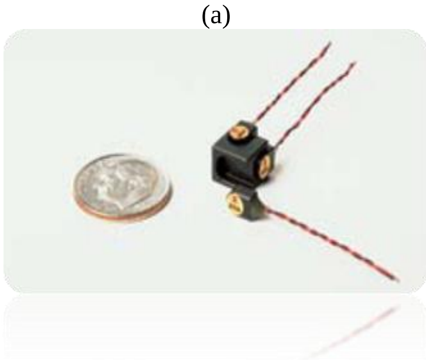
The problem associated with the stain gauge accelerometers was their full scale output voltage response is poor in orders of milli volts (approximately 20mV) hence to increase the frequency response is limited due to signal to noise ratio. In order to improve the stiffness fluid damper often used at damping ratio of 0.707 thus improve the frequency response three folds but the consequences of improved frequency response by additional damper is system becoming mote temperature sensitive when operated above 30 degree faurienheat. It can be concluded that for wide applications with different frequencies of responses cant be achieved by a single accelerometer thus limited to few applications related to high frequency vibrations.

The promising solution for the limitations discussed above replaced by piezo electric accelerometers into the measurements domain. The peculiar features like high moduli and self generating signal output ability in wide ranges made the piezoelectric materials well suited for accelerometer design with high resonance frequencies hence there no need for additional damping to the system and also eliminated the phase shift of operated frequency range of accelerometer. The piezoelectric accelerometers has less foot print compared to strain gauge based accelerometers. flat frequency response has improved up to 10K Hz in piezo electric scenario where as in strain gauges based accelerometer near 200 Hz.

The decade between 1940 to 1950, a good number of manufactures came forward for the piezo electric accelerometer making. The material which posses piezoelectric behavior are ferroelectric and non ferroelectric like quartz. Barium Titanate is the manufacturers choice as ferroelectric ceramics used. The first Accelerometers with conjunctive signal conditioning unit is encapsulated as a unit produced by Brüel & Kjær (B&K) is located in Naerum in 1943, Denmark designed for vibrational measurements. This accelerometer made up of square bender plates over which rochelle salt crystals are mounted. Device features like sensitivity and resonant frequencies are 35-50mv/g , 2-3kHz respectively as recorded in the literature. Next decade improved models were designed one of which by B&Ks U. S proposed shear mode accelerometer with model number as 8307 in 1972, extended version of this model named as Delta Shear a registered design in 1974 for base strain lose minimization and thermal coupling. The brand B&K manufacturer has released a piezo electric accelerometer(model number 8309) with a range of 100kilo g for vibrational analysis. During the early 80's till millennium accelerometers occupied wide domain like nuclear power plant operations, irrational measurements in airborne hybrid assemblies , shock analysis.

Another pioneers, Gulton Manufacturing from Metuchen, New Jersey patented the process barium titanate a first man made piezo crystal .. PCB electronics in 1971 announced a 100,000 g shock accelerometer in 1971. Another one named Endevco introduced a micro machined accelerometer for high shock( 1lakh g) measurements applications with temperature calibration along with the charge amplifier. From the literature, the first silicon based micro machined piezo resistive accelerometer attempt made in 1962 under patented rights from PCB can see in fig:2

(a)



(b)

***Figure 2 Endevco current accelerometer technology: (a) Model 7270A sculptured silicon shock accelerometer; (b) Model 25A 3-axis configuration microminiature accelerometer with integral electronics (1996).***

Since 1930's accelerometers commercial usage got drastically increased many vendors evolved and proposed the newer possibilities of using accelerometers in various engineering domains. This paper presents the commercial vendors of accelerometers Analog Devices ,Bosch, Dytran, Hitachi Metals, Matsushita EG&G IC Sensors, Endevco, Honeywell, Digisens, Freescale, MemsIc, Entran Devices indsensors, Summit Instruments are few among many.


**Figure 3 Accelerometer manufacturer**

The expansion of usage and availability in large number is because of significant improvement in IC technology as well as semiconductor industry. So as a result there is a considerable growth in utilization of the accelerometers. MEMS(Micro-Electro-Mechanical- Systems) industry promises the possibilities of miniaturizing the accelerometers with wide varieties of material , fabrication and packaging lead to invention of new principles in the field of MEMS accelerometers, after the piezo resistive and piezo electric accelerometer impact on Evaluation and Testing industry Capacitive based MEMS accelerometers took over a major stack as a choice of accelerometer selection.

The primary user domains to make use of accelerometers was test and evaluation (T&E) for military dynamics and aero space machine monitoring and maintenance applications . The automobile industry adopted the MEMS accelerometer as versatile sensor system. This interest driven the manufacturers to look forward for better accelerometer in measurement specifications as well as low cost perspective. At present MEMS accelerometer are preferred due to their low frequency response. The key aspect of reviewing the present work is depends over the accelerometer sensing ability at low frequencies.

Industry choice of MEMS accelerometer is depends on following factors, Low Cost, high reliability, ability to interface with external hardware i.e signal conditioning, self test circuitry. By keeping these factors into consideration Analog Devices has announced ADXL50 accelerometer in 1993 as it first commercial product made in large number has foot print of 5 $mm^2$ aimed for auto mobile airbag deployment application. Now a days accelerometers are part of other measurement mechanisms for collaborative assessment of motion application give raise to IMU( inertial Measurement Units) where MEMS accelerometers are coupled with gyroscope for better space orientation analysis often used for device stability control, load leveling. anti collision assistance and navigation. Accelerometer has made a clear impact over the consumer product like game controller, mobile phones and hand held gadgets also i significant usage in robotics and bio medical applications.

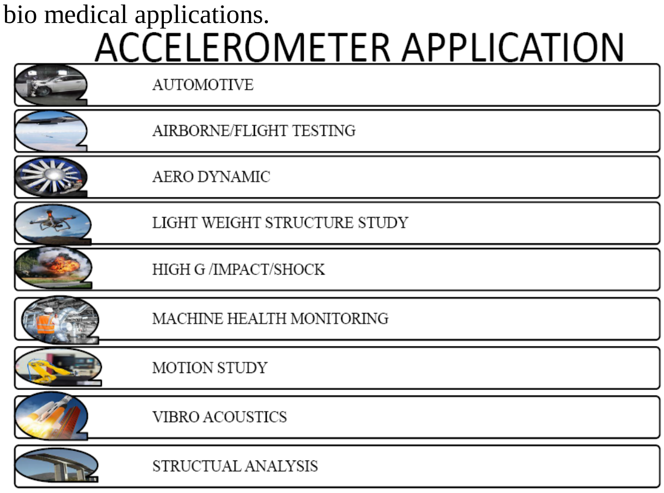



**Fig:4 MEMS accelerometer application**

**Table 1. Accelerometer Grade and Typical Application Area**

| Accelerometer Grade | Main Application | Bandwidth | g-Range |
|---|---|---|---|
| Consumer | Motion, static acceleration | 0 Hz | 1 g |
| Automotive | Crash/stability | 100 Hz | <200 g/2 g |
| Industrial | Platform stability/tilt | 5 Hz to 500 Hz | 25 g |
| Tactical | Weapons/craft navigation | <1 kHz | 8 g |
| Navigation | Submarine/craft navigation | >300 Hz | 15 g |

The future of the accelerometer lies in using them the field not explored so far namely concentrating on biological and biomedical sectors where there is enormous scope of assessment of tiny moments for the better diagnosis of deceases. as a prophecy with the literature support Surely accelerometer will impact the medical domain as never before in ways we cant imagine

The major objective of this review work is to enable the reader to wisely select the accelerometer for the possible bio applications hence to it is necessary to understand the accelerometer more closely with the support of principle of sensing behind their measurements. Accelerometers are sensors widely used in the measuring shock, vibration, tilt, acceleration in other way there are for measuring the acceleration of a moving or vibrating body. Single- and multi-axis models of accelerometer are available to detect magnitude and direction of the proper acceleration (or g-force).

basic physics behind sensing is when a moving or vibrating applies a force on the transduction mechanism called as transducer , the mechanical higher order system undergoes change in position which is captured using different principles namely recorded till date in the literature are Piezo resistive , piezo electric, capacitive, halffect, thermal(heat tranfer), Tunneling and Optical methods.

As a nutshell to describe accelerometer physically a micro machined electromechanical device, with hole ,channels, limbs ,springs, layers, metal pads etc., using advanced IC fabrication technology, it is constructed in clean room facility , with multi layered silicon deposition process ,ultimately measuring the acceleration by detecting the movement of proof mass with respect to the fixed frame.

$m\ddot{x} + b\dot{x} + kx = F(t)$, *Natural frequency*= √ (k/m)

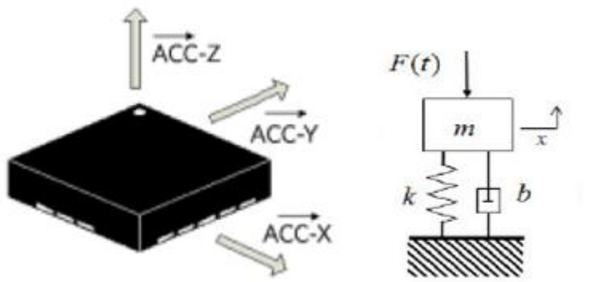
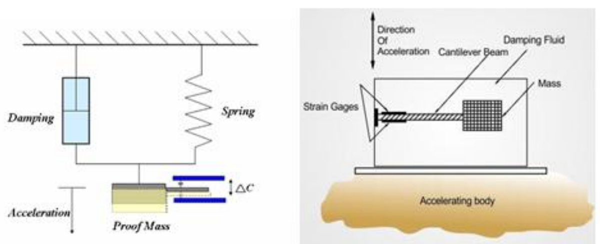
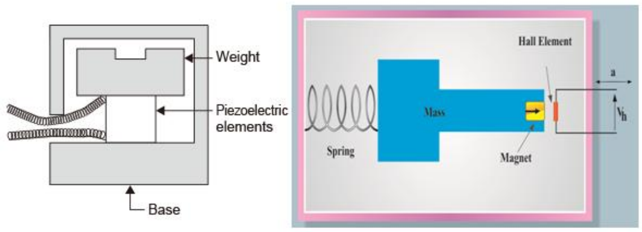


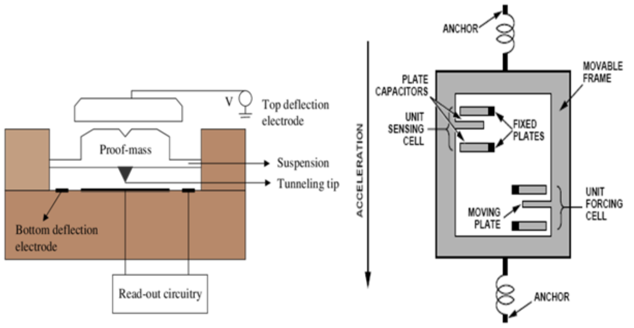

**Figure: Mechanical modeling of Accelerometer as second order system**



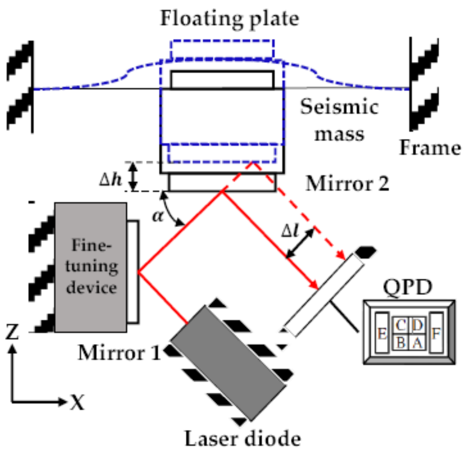

a) Capacitive b) Piezo resistive




c) Piezo electric d) hall effect




e) Tunniling f) Heat tranfer




g) optical

**Figures 5: a) to g) Various sensing principles of accelerometers**

The figure shows the schematic view of various sensing principles incorporated in accelerometers while detecting the acceleration exerted over the suspended proof mass. The crisp details of various sensing principles are described below.

capacitive accelerometers detects the acceleration as a change in electrical capacitance when the proof mass limbs accelerates between the fixed beams of the structure, the effective capacitance change is proportional to the acceleration of the proof mass of the structure.

In Piezo resistive type, the governing principle is piezo resistive effect , during the acceleration of the proof mass the piezo material stressed leads to change in resistance in turn the effect of change in resistance is converted into voltage using Wheatstone bridge circuit.

Piezo electric accelerometers are works on the principle of piezo electric effect, as per this the piezo material undergoes stress due to proof mass during the acceleration , as a result charge accumulated across the piezo material , using a readout circuit charge is converted into voltage which is proportional to acceleration applied.

In Hall effect accelerometers, transduces the proff mass movement into voltage using proximity effect of proof mass magnetic field to biased semiconductor device produces hall voltage.

Heat transfer Accelerometers sense a change in heat exchange across the thermal sources in side a encapsulated mechanical system into electrical voltage using thermal transducers.

The accelerometers with tunneling sensing principle able to measure acceleration as the tunneling tip induced the tunneling current for input movement , so as to maintain the current constant the driving voltage be made proportional to the input acceleration.

In optical based accelerometers, for the applied inertia ,seismic mass oscillates. A light beam triggers on the plan of proof mass , collected back at photo detector end, moving system leading to change the reflection further observed by photo detector.

Among the listed principles capacitive accelerometers fits is many application replacing the traditional accelerometers worked over piezo resistive and electric principles due to several advantages like sensitivity, simple transduction readout circuitry, low noise, less immune to temperature, linearity and sensor die area.

Selection of suitable Accelerometer: It is important for the designer to chose the right sensor for the specific application if not the measurement activity suffer with poor accuracy and reliability. As per the technical guidelines provided by the Analog devices company, suggested end user to concern over typical accelerometer features like Axis of sensing, Noise, g-range, power consumption and band width . the picture depicts the ADXL series of analog devices. features versus application domain for varieties ADXL series of accelerometers. The key specification definitions are:

*Sensitivity of accelerometer* is the ration of voltage obtained from the transduction to input g force and its measuring units are over mV/g. *Frequency response of Accelerometer* is a bode plot for understanding the stability of the accelerometer also correlated with the sensitivity, the range of frequencies for which sensitivity of accelerometer will not change is termed as bandwidth.

*Brownian Noise* play a key role in deciding the resolution of the accelerometer measurement. from the mathematical expression noise can be minimized by the subsequent raise in the proof mass of the structure. g- Range provides the capability of acceleration or impact measurement of an accelerometer at present scenario accelerometer are able to sense the g range from $10^{-9}$ to $10^{6}$ g.

$$\sqrt{\frac{a_n^2}{\Delta f}} = \frac{\sqrt{4K_BTb}}{m} = \sqrt{\frac{4K_BT\omega}{mQ}}$$

where

an = Brownian acceleration noise,Δf = Bandwidt, KB = Boltzmann constant,T = Absolute temperature in Kelvin.

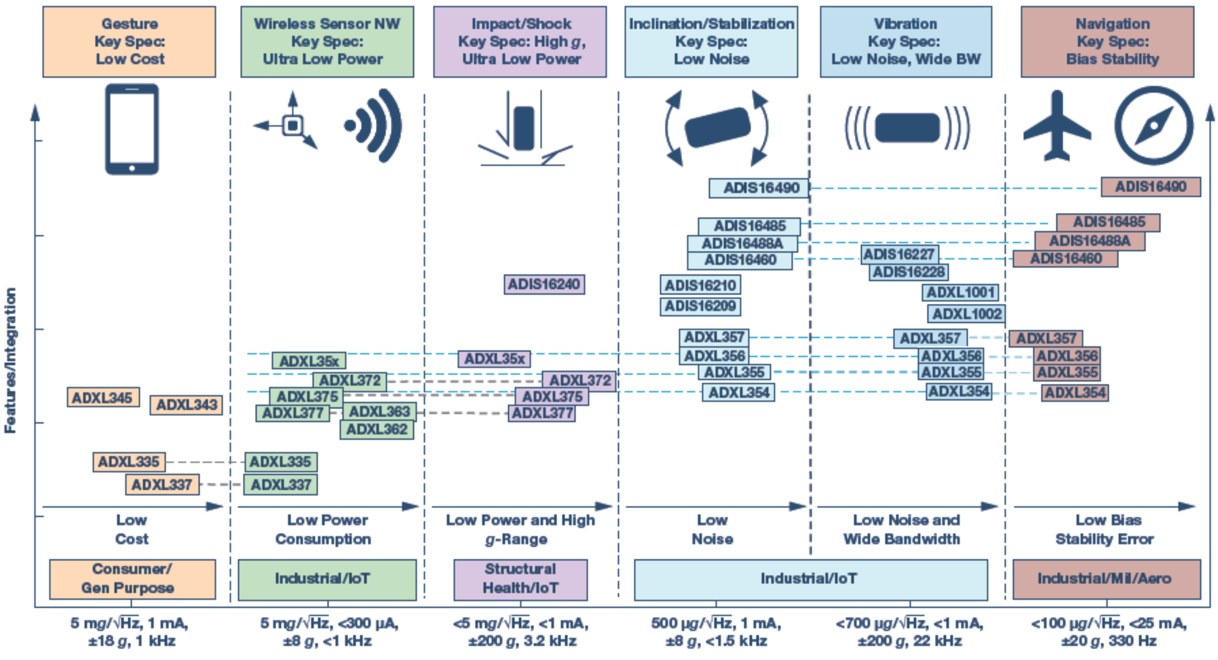



**Figure 6: Analog devices accelerometer selection criteria based on device feature**

| MANUFACTURER | ACCELEROMETER IC MODEL & FEATURES |
|---|---|
| *MEMSIC* | MXD2020E - Digital PWM output, ± 1g<br>MXD6025 - Digital PWM output, ± 2 g<br>MXD6125 - Digital PWM Output ± 0.5 - 2 g<br>MXD2125GL/HL/ML/NL - ±2 g Dual Axis Accelerometer with duty-cycle output<br>MXD6235M - ±2 g Dual Axis Accelerometer |
| *HONEYWELL* | RBA-500 - Frequency Output Sensor (Accelerometer) |
| *ANALOG DEVICES* | ADXL202,210,213 - Accelerometer with Duty Cycle Output, 2-Axis Acceleration Sensor on a Single IC Chip ± 1.2 g<br>ADXL001-HighPerformanceWide, Bandwidth Accelerometer, ±70 g, ±250 g, ±500 g<br>ADIS1620,16003,16006,16204 - Low Power Fully Self-Contained Accelerometer/Inclinometer, 12 Bit Digital Inclination/Acceleration Sensor Output,Programmable Hi-G Digital Accelerometer, Impact Sensor, SPI output, Dual-axis sensing, ±70, ±37 g, 14-bit resolution |
| *BOSCH* | SMB48x/49x - 4th Generation Micro-Machined Accelerometers; ±120 g and ±480 g; Digital PSI5 two-wire current interface |
| *FREE SCALE* | MMA7455L - ±2g/±4g/±8g Three Axis Low-g Digital Output (SPI/I2C) Accelerometer |
| *STM ELECTRONICSs* | LIS3LV02DL - three-axis digital accelerometer. SPI/I2C digital interface, ±2 and ±6g full-scale acceleration ranges that can change by software command before and during operation<br>LIS302DL - MEMS motion sensor 3-axis ±2g/±8g smart digital output 'piccolo' accelerometer<br>AIS326DQ - MEMS inertial sensor 3-axis, low *g* accelerometer with SPI digital output |
| *SUMMIT INSTRUMENTS* | 35203A, 35200A - Digital Accelerometer. Telemetry configuration, RS-485, CRC-16 error checking. |
| *MIND SENSORS* | ACCL-Nx-v2 - Multi-Sensitivity Acceleration Sensor, I2C interface. Tilt data resolution in each axis: 2.5 degrees. Supported sensitivities: 2.5G, 3.3G, 6.7G, 10.0G |
| *TECHKOR INSTRUMENTS* | M9E-RF-1-50G - Wireless Smart (TEDS) Accelerometer |
| *SILICON DESIGNS* | Model 1010 - Digital Accelerometer, pulse density output<br>Model 2010 - Single axis accelerometer module. Pulse density output<br>Model 2420 - Triaxial accelerometer module, pulse density output |

**Figure 7: Various Manufacturer Accelerometers models**

the fabrication procedure helps in understanding the ways how to realize the accelerometers into existence. the fundamental process is named as Micromachining, has two approaches TOP DOWN and BOTTOM UP. Surface micro machining is Bottom up process where structures are deposited layer over the layer using various deposition techniques. In top down approach bulk silicon wafer is etched with appropriate chemicals solvents. There are no standardized finite steps defined for accelerometer due to the design specification and material specification and limitations. the top down and bottom up process has their own advantages and limitations hence new fabrication processes are evolved. Bottom up process realize thin accelerometer structures which has more suceptance toward noise and suffer with stiffness issues . Top down has complex fabrication procedures consumes time and device design complexities leads to complex fabrication processes. one has to chose optimal way to realize the accelerometer to achieve better performance.

## II. ACCELEROMETERS FOR BIO MEDICAL AND BIOLOGICAL DOMAINS

The core objective of the paper tuned towards the possibilities of accelerometers usage in biomedical and biological domains. Literature provides valid support to conclude the scope of applications of accelerometers based on the fact that the knowledge of human body moment of inertia is a vital note for understanding the bio mechanics of human body. Human body collectively made of tissues which get distorted when human body tends to change the position in different axes of rotation and movements as there was no specific methodology exist to estimate the moment accurately.

Accelerometers are best suited for the above problem as they measure external acceleration force with respect to reference axis. The flexibilities of incorporating 3axis mechanism allows accelerometer to identify the moments in multiple direction simultaneous hence best suited for the human body movements.

The healthiness of living beings like human and animals that crawl and fly is estimated by the observational measurements. accelerometers were popularly used in recording the tiny frequencies of movements of various body components like heart beat, lung expansion , gestures moments, joint bio mechanisms.

The Most popular and successful MEMS accelerometer used in bio applications to monitor cardiovascular diseases. The sudden death rate due to cardiac arrest can be prevent effectively by the early prediction of its symptom. The implantable MEMS accelerometers with additional pulsatory circuit is popularly called as "pacemaker". Literature emphasizes that over 0.2 million implantation of pacemaker happening all over the world. Pace maker regulates the heart beat by providing electrical impulse to activate heart tissue which promises the natural heart rhythm.[16]

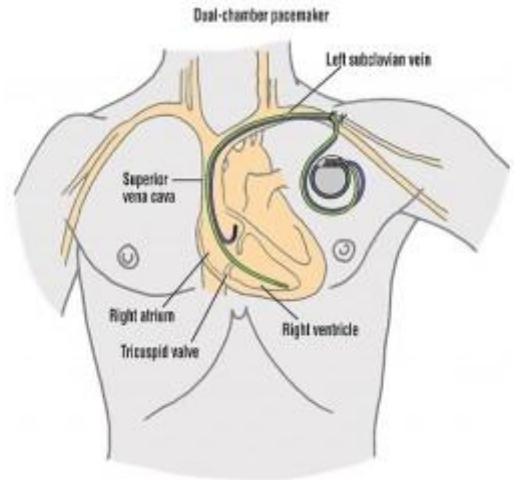



**Figure8: Pace maker**

Telemetric accelerometers in bone healing therapy gave successful results. The idea behind using the accelerometers to sense the micro movements with at most precision for the optimal healing progress of the bone, by this method it's been observed that improved rate of healing and reduction in the complications encountered during the process of curing hence patient get ensure of his quality of life. Figure depicts the telemetric accelerometer healing process setup for the a buffalo , modlue consists of telemetry component like antenna with accelerometer attached to the third metacarpal bone over hoof.


**Fig9 : Hoof-mounted accelerometer & telemetry unit,**

Another health sector where accelerometer usage is extensive is health care in which popular application are gait analysis, sleep sensing and fall detection. The gait analysis is a clinical approach for the early detection of parkinson disease and stroke. In fall detection scenarios early fall is accurately recognized to take immediate actions. Machine learning algorithms used to categories the accelerometer sensor data. Sleep monitoring is a key aspect in safety as well as human health indicator. The quality of sleep can be in terms of duration , regularity and deepness. Accelerometer based monitoring system is trendy and effective. Accelerometers are implanted into electronics gadgets like wrist watch brand wristband, jaw bone., xiomi etc,. monitors the sleep.

early years for bio application accelerometers are used in marine research to understand the species habitats, animal borne accelerometers are operated over sea birds , penguines, mammals like seals , turtles and wide range of aqua species. The authors Graf PM, Wilson RP, Qasem L, Hackländer K, Rosell F[15] recorded that the use of 3 axis accelerometers popular due to miniaturization with embedded features like data logging capability to trace the spatial moments. Acceleration recorded was in the range of +/- 4 g with the range of frequency between 2 to 8 Hz.

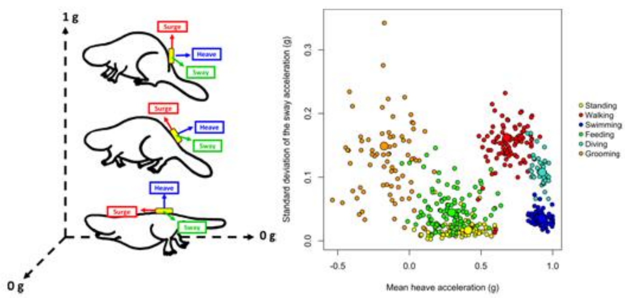



**Figure 10: Accelrometer application-Changes in Eurasian beaver posture. Changes in orientation of the surge, sway and heave acceleration axes are illustrated during standing, walking and swimming (top to bottom)**

The most recent activity , for an animal telemetry, accelerometers were used to understand the sharks hunting habits. A team from polar research institute in Japan recorded the white shark gazing over a period. Acceleration measurement helped to identify the predation events during swimming and hunting. specifications of recorded lateral acceleration is 3.7g with 3.3Hz frequency response [14]

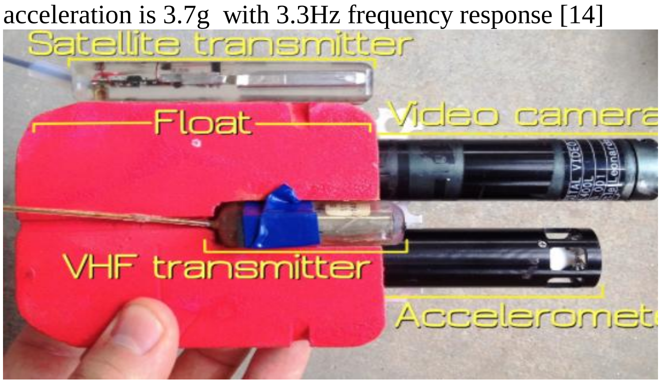



**Figure 11: Implanted Accelerometer and other electronics units into animals for future recovery**

## III. Material Compatibility

The most popular material used in MEMS industry is Silicon due to its remarkable electrical and mechanical properties such as stability, young's modulus and it has become favorite material for the IC industry due to well documented manufactured procedures of single and poly crystalline silicon. The primary form of silicon is used as substrate to the MEMS structures. Silicon Compounds like silicon dioixide , silicon carbide silicon nitride and poly crystalline silicon are functional opted material . For fabricating the MEMS accelerometer wide varieties of materials used because of mechanical and electrical , thermal properties taken into consideration.

| Material Parameters | single crystal silicon | Poly-silicon | SiN (LPCVD) | $SiO_2$ (LPCVD) | Gold | Al | SiC | Stainless steel |
|---|---|---|---|---|---|---|---|---|
| Young's Modulus E (GPa) | 130-187 | 120-175 | 254-385 | 73 | 78 | 70 | 700 | 192-200 |
| Density (Kg/M$^3$ ) | 2300 | | 3100 | 2500 | 19300 | 2700 | 3200 | 7900 |
| Fracture strength (GPa) | 0.6-7.7 | 1-3 | 14 | 8.4 | N/A | N/A | 21 | 21 |
| Poisson ratio (υ) | 0.25-0.36 | 0.13-0.36 | 0.28-0.3 | 0.17 | 0.42 | 0.33 | 0.16-0.24 | 0.30 |
| Thermal conductivity (W/mK) | 157 | 34 | 19 | 1.4 | 315 | 247 | 71-490 | 33 |
| Linear thermal expansion coefficient (ppm/°K) | 2.33 | 2.33 | 2.7-3.7 | 0.55 | 14.2 | 25 | 4.2-5.6 | 4.4-27 |
| Thermal Conductivity (J/Kg/K) | 700 | | 700 | 740 | 128 | 900 | 590-1000 | 420-500 |
| Electrical resistivity (MΩ ) | | | N/A | N/A | $2.3x10^{-8}$ | $2.6x10^{-8}$ | N/A | $5.5x10^{-7}$ |
| Piezoresistive gauge factor | ~100 | 10-30 | N/A | N/A | 1-4 | 1-4 | N/A | N/A |

**Table 2: Common material used and their properties in MEMS accelerometer fabrication**

| Accelerometer Sensing principle | Materials Used | Reason | Disadvantage |
|---|---|---|---|
| Capacitive type | Silicon, Polysilicon,SiC,Si3N4 | High sensitive, linearity in input and output relation establishment, high temperature capability | Large space while making, harsh environment impacts, interference effcts |
| Piezo resistive Type | Silicon(Dopped), GaAs (Galium arsenide ) and polymers | Size and high sensitivity to strain | Temperature dependency deteriorates the sensitivity |
| Piezo electric Type | PZT, Barium Titanate, | Active transducer, Dynamic measurements | Brittle nature, Size and mechanical ability |
| Hall effect | | | |
| Tunneling | Si,Ti/Pt/Au | High sensitive, less space | Noise at low frequencies |
| Heat Transfer | | | |
| Optical Type | | High sensitive ,Insensitive to noise, high frequency response | Electronics integration, |

**Table 3: Accelerometer Material Preference**

## IV. Fabrication Challenges

MEMS has two fundamental micro machining techniques they are surface micro machining and bulk micro machining. . Silicon micromachining is the process of creating microscopic mechanical parts out of a silicon substrate, specifically, on top of a silicon substrate. There are no specific documented procedures to fabricate a variety of mechanical structures including beams diaphragms, grooves ,orifices, springs ,suspensions gears and other complex mechanical structures.

## V. Scope of Novelty and Reach Ability

Globally the design engineers are modeling novel accelerometers for based on the specific application due to which materials and process methods of fabrications are getting varied make accelerometer making more complex. Advancements in MEMS packaging allows an concealed signal conditioning electronics required for the accelerometer make them "read ready" or interface ready. The plug and play model of accelerometer are more fancy to incorporate them in motion based application.

Accelerometers are integrated with the other sensors over a common silicon substrate to make sensing more reliable and compact , this integration take a giant leap in fabrication challenges of integrating multiple sensing principles based accelerometer for better analysis. In bio medical application, shaking, vibes, moments are to be realized more precisely for development of self diagnosed gadgets and ease of monitoring wirelessly. Accelerometers are best choice to used, in keeping the market requirement for new sensor applications.

## VI. CONCLUSION

The MEMS accelerometers market has entered into an accelerated growth. Earlier success of Pressure sensor and accelerometers gave a promising exploration into the new domains. As there is no bound to+/- g measurement, applications in low "g" measurement and high "g" measurement in bio medical domain challenges the experts in terms of innovation in material and designing as the world trending toward miniaturizing in pollution and better quality energy usage. In the twenty first century, Bio MEMS accelerometer devices are expected to be revolutionize inertial measurement requirement in health sector. the Existed research enlightens the great scope of MEMS accelerometers into bio medical industry. The opportunities in Bio medical domain are huge for accelerometer due to the flexibility in design for application specific sensing, also feasibility for novel due to bio compatible requirements. Discussion are made over the varity of methods of acceleration assessment and material challenges.

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