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Biocompatible piezoelectric microstructures utilizing eye motion for self-sufficient IOP-sensor devices

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Introduction

Implantable sensor devices for long-term supervision of physiological parameters require miniaturized, maintenance-free and biocompatible power supplies. In particular, an intermittently operated, minimally invasive monitoring system for intraocular pressure, composed of a pressure sensor, energy storage capacity, a signal transfer and harvester unit, sets strict limitations on size and vibrational excitation. This work predominantly aims at the demonstration of novel approaches in human-based vibrational energy harvesting from human motion.

Methods

Unlike the artificial, narrow-band, harmonic vibrations of technical ambience, human-induced vibrational energy harvesting necessitates a specific consideration of the excitation spectrum (stochastic, 3-dimensionally superimposed, low-frequency signature). For different everyday situations triaxial recorded head accelerations (e.g. walking, head shaking) and eye tracker measurements (gaze shift, text reading, video watching) are presented. Miniaturized piezoelectric transducers made of aluminium nitride (AlN) thin films offer excellent mechanical stability, biocompatibility (lead-free) and integrability into microelectronics and pressure sensor. Different MEMS architectures formed of AlN-membranes, unimorph and bimorph cantilevers were designed, fabricated and characterised simultaneously.

Results

Eye tracker measurements confirm literature values, showing saccadic durations of ≈ 60 ms and peripheral accelerations of ≈ 3.3 ms^{-2} for 20° horizontal saccades. Higher-frequent, low-amplitude oscillations of microsaccades and nystagmus are overlaid. High-compliant inertial bimorph transducer show very low resonant frequencies (f_0< 80 Hz) and higher material utilization, enabling an efficient excitation by saccadic eye movements. On the contrary, corrugated membranes will not need any vacuum encapsulation.

Conclusion

For an optimised geometry towards maximum power generation, dynamic tuning between harvester and source is crucial. Since the power generation is still insufficient, serial and parallel assemblies of in-phase oscillating harvesters will increase the power output.