Electret based Vibration Energy Harvester with Integrated Silicon Tips Used for Corona Charging

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☑Participating in the Student Poster Competition? (First author must be full-time student and attend the conference)

Recently, with the fast development of internet of thing (IOT) techniques, the need of wireless sensor nodes has continued to increase. The electret-based vibration energy harvester (e-VEH) provides an effective way for the power supply of these wireless node. The typical e-VEH can be seen as a variable capacitor containing a resonant spring-mass structure. And the electret is coated on one side of the capacitor to provide a bias voltage. When the spring-mass structure motivated by the outside vibration source, the charge will be induced on the electrodes and moving across the external load. [1] But in fact, the charge stored in electret will greatly decay in high humidity or other poor environments. To recover the charge in electret the common way is taking apart the device and charging the electret again. Whereas this method is risky and time-costing because MEMS devices are generally brittle.

In this paper, we proposed a e-VEH with the out-of-plane gap closing scheme integrated with silicon tips, which could be used to recharge the electret surface again without detaching the packaged device. The fabrication process flow is shown in Figure 1. The SiO_2 on (100) silicon wafer is etched to squares as masks with 200μm long by BOE. Then the silicon wafer is wet etched in 40% KOH solution at 50°C until the silicon tips take shape. As shown in Figure 2, the silicon tip is with height of 89.6μm and width of 80.7μm. After that the wafer is deposited with 200nm SiO_2 by PECVD and a metal multilayer of Cr/Al (15nm/100nm) on the surface of tips by sputtering. Finally, the top plate with tips is assembled with bottom plate containing spring-mass structure using PVC as spacer to control the initial gap between proof mass and silicon tips is 350μm as shown in Figure 3.

The charging test of our e-VEH uses a DC power supply and a 2000 times voltage boost module connected to the metal layer on tips as shown in Figure 4. After corona charged 5 min by integrated tips applied 6000V voltage on 7*7 tips, the result is shown in Figure 5, we can find the area with significant voltage increasement is at the edge of the proof mass. After that we test the output power of the device before and after charged with different voltages with acceleration of 9.8 m/s^2 as shown in Figure 6. The resonant frequency of this e-VEH is 125 Hz. As the charging voltage increases, frequency of disruptive discharge increases so it has higher output power. But as applying 6000V voltage, the edge of top plate begins to disruptively discharge the bottom plate causing worse performance. Finally, the matched load resistance is tested with the device charged by 5000V at RMS acceleration of 9.8m/s^2 where the external sinusoidal vibration frequency is 125Hz as shown in Figure 7. The optimum power output is 0.92μW at 31MΩ load resistance.

With the integrated charging tips, vibration energy harvester could be more recycling and have higher lifetime.

References

[1] Yulong Zhang et.al, “Electret based vibration energy harvester with self-healable surface charge,” IEEE MEMS 2019.

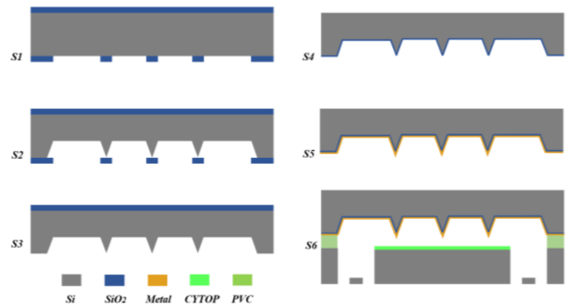

Figure 1. Fabrication process flow of the energy harvester.

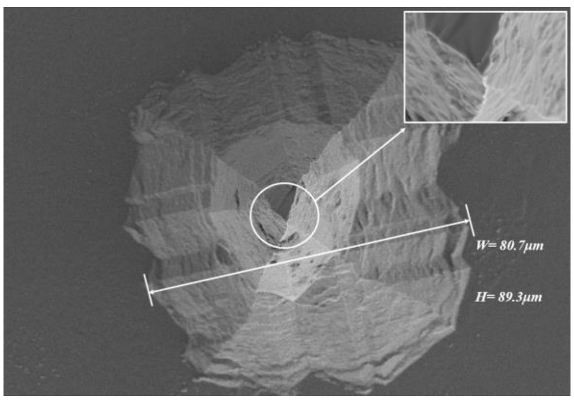

Figure 2. SEM photo of the silicon tip.

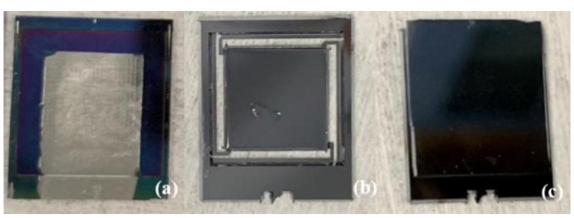

Figure 3. (a) Top plate with silicon tips. (b) Bottom plate with spring-mass structure. (c) The final device after assembling.

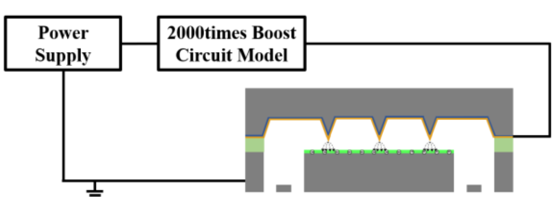

Figure 4. The schematic diagram of charging test system for e-VEH.

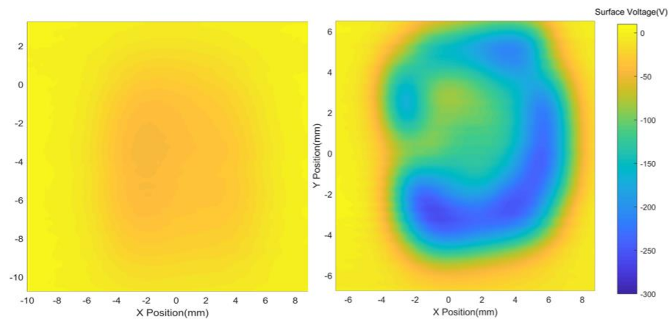

Figure 5. Surface potential of electret before and after charging using integrated tips.

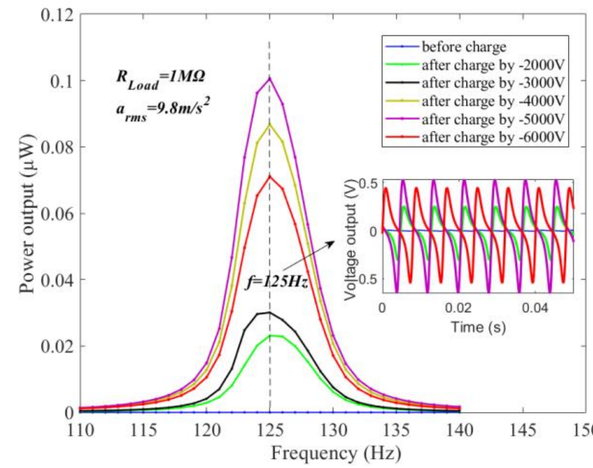

Figure 6. Power outputs of the e-VEH on 1MΩ at 9.8m/s^2 with different charging voltage.

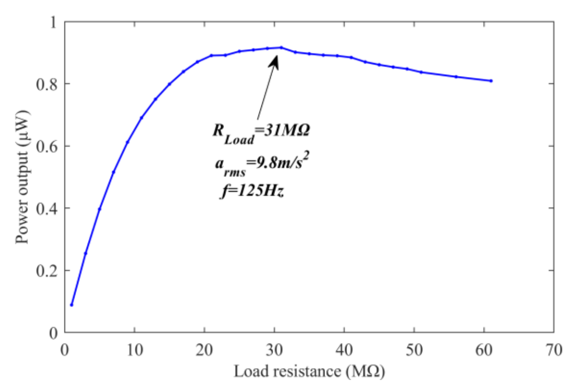

Figure 7. Power output of the device charged by 5000V when the external load increases from 1MΩ to 60MΩ at RMS acceleration of 9.8m/s2 where the external sinusoidal vibration frequency is 125Hz.