A High Voltage MEMS Needle Plasma Switch for Electret Energy Harvester Conditioning Circuit

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Introduction

Electret energy harvester could be a potential solution for distributed sensor networks and wearable devices. But with the principle of electrostatic induction, the application of electret energy harvester is limited by its high internal resistance 、 high voltage output 、 low current output, which also challenge the conditioning circuit.

Previous research on efficiently utilizing the power of electret energy harvester have proven adding switches into conditioning circuit could significantly improve output performances[1-4]. Inspired by electrostatic discharge, Zhai[3] et al established a pair of copper needle-to-needle plasma switch packaged in Argon atmosphere to enhance the performance of electret energy harvester. Thanks to the plasma discharge, the voltage increased from 300V to 1300V and the current increased from serval μA to 16mA. But the assembling is under a microscope, the manufacturability is not good.

In this paper, we design and fabricate a SOI MEMS needle plasma switch whose chip size is 2mm×4mm. The needle structure MEMS plasma switch can work normally when connected in series in the circuit. With the inducted high voltage and the profile curvature at the needle tip, a high-intensity non-uniform electric field is formed between the needle tips so that gas discharge occurs. The energy starts to transfer through the plasma conductive path and stops when the electric field strength decreases, thus forms energy convert cycles. Rectified by a half-wave rectifier, with the principle of corona discharge, the maximum output voltage of e-KEH is increased by 40%(700V) and the maximum output current increased by 1025%(80μA).

Results and Discussion

The experiment results are shown in Fig.1. The original output of the electret energy harvester is -600V to +500V AC voltage output and ~8μA AC current output. Rectified by half-wave rectifier circuit, with the MEMS plasma switch, the output is ~600-700V pulse DC voltage and ~90μA pulse DC current. Fig.1 shows the voltage and current performance through the MEMS plasma switch in comparison with original output. Acquired maximum voltage is 700V and increased by 40%. Acquired current is 90μA and increased by 1025%.

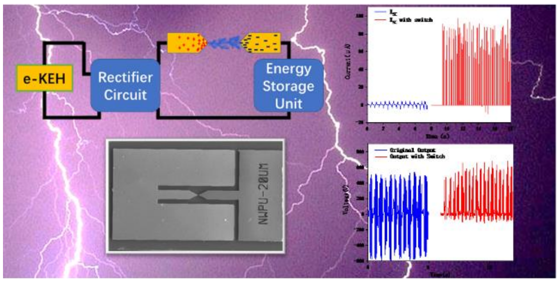

Figure 1: The graphical abstract. The schematic design of the system, SEM image of MEMS needle plasma switch and its voltage and current performance enhancement.

Conclusion

Based on previous research, in order to solve the problem of high performance passive switch design, a corona discharge MEMS needle plasma switch is established. The performance is characterized and shows significant voltage and current boost performance. With a compact size and such significant power boost performance, the MEMS needle plasma switch has the potential to integrate with high-efficiency energy management circuits and supercapacitor energy storage devices.

References

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