8th Asia-Pacific Conference on Plasma Physics, 3-8 Nov, 2024 at Malacca

Performance tuning of triboelectric nanogenerators based on corona discharge and charge visualization

Yi Luo[1], Yi Li[2], Cheng Zhang[1], Bangdou Huang[1], Tao Shao[1]

[1] Beijing International S&T Cooperation Base for Plasma Science and Energy Conversion, Institute of Electrical Engineering, Chinese Academy of Sciences, [2] State Key Laboratory of Power Grid Environmental Protection, School of Electrical Engineering and Automation, Wuhan University

e-mail: luoyi@mail.iee.ac.cn

Triboelectric nanogenerator (TENG) manifests distinct advantages such as multiple structural selectivity, diverse selection of materials, environmental adaptability, low cost, and remarkable conversion efficiency, which becomes a promising technology for micro-nano energy harvesting and self-powered sensing. TENG operates on the principle of utilizing contact electrification and electrostatic induction. Therefore, the surface charge density of triboelectric materials is closely related to the output performance of TENG[1-2].

Numerous methods have been proposed to boost the output performance, aiming to improve the effective surface charge density. One of the simple approaches to introduce charges into the triboelectric layer is through ion injection and corona discharge[3]. As for corona discharge injection, the ions generated by air ionization under high voltage were deposited on the sample surface. The utilization of the tip-plane electrode produces a highly uneven electric field, leading to the creation of charge spots with an irregular distribution. Meanwhile, it is challenging to realize accurate surface charge deposition through corona discharge by traditional tip-to-plane electrodes. The key is the lack of charge visualization method.

Herein, we achieved the visualization and standardized quantification of surface charges for triboelectric materials. The surface charge imaging method based on the flexible Golub-kahan hybrid approach was proposed first, which realizes the visualization and quantification of surface charge distribution using surface potential measured by the electrostatic probe. Further, we explored the interfacial charge exchange process of contact electrification and introduced a three-electrode system for single polarity charge injection. We achieved the triboelectric polarity tuning of polytetrafluoroethylene (PTFE), by injecting negative or positive charges. This work provides a beneficial tool for visualization and standardized quantification of surface charge, promising to advance a deeper understanding of contact electrification and customizable design of high-performance TENGs.

This work is supported by the Postdoctoral Fellowship Program of China Postdoctoral Science Foundation (Grant No. GZC20232635)

References

[1] Y. Li *et al*, Adv. Mater. 2314380 (2024)
[2] Y. I. Sobolev *et al*, Nat. Phys. **18**, 1347-1355 (2022)
[3] W. Liu *et al*, Mater. Today **45**, 93-119 (2021)

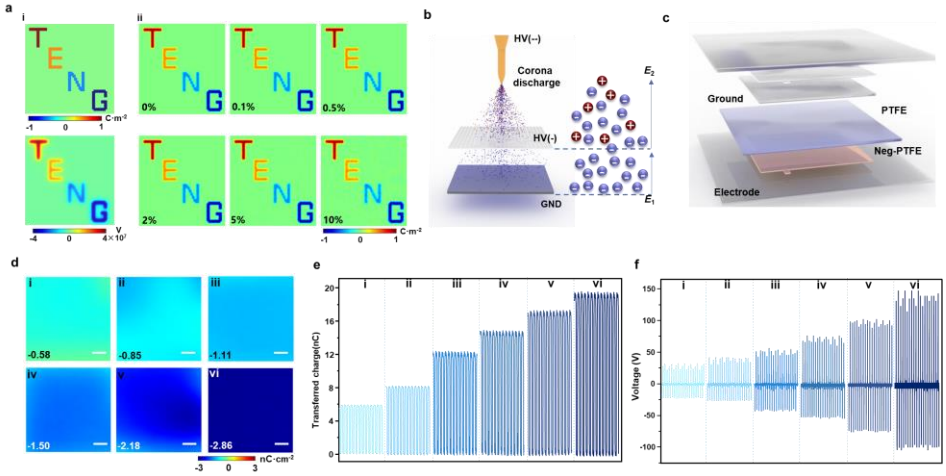

Figure 1. **a** i) The artificially set "TENG" letter-like charges and the induced surface potential distribution. ii) The obtained surface charge distribution under different Gaussian noise conditions by the hybrid method. **b** Schematic illustrations of the three-electrode system for single polarity charge injection. **c** Schematic illustrations of the neg-PTFE/PTFE triboelectric pair-based TENG. **d** Tuning and standardization of negative surface charge on PTFE, i) -0.58 nC·cm-2, ii) -0.85 nC·cm-2, iii) -1.11 nC·cm-2, iv) -1.50 nC·cm-2, v) -2.18 nC·cm-2 and vi) -2.86 nC·cm-2 (Scale bar: 3 mm). **e-f** The e) transferred charge (Qsc), f) output voltage of neg-PTFE/PTFE triboelectric pair based TENG with different negative surface charge density (2×2 cm2, F = 50N). A 70-fold enhancement is achieved on the output voltage (~135.7 V) for the identical PTFE based TENG (neg-PTFE/PTFE or posi-PTFE/PTFE triboelectric pair) with stable surface charge density.