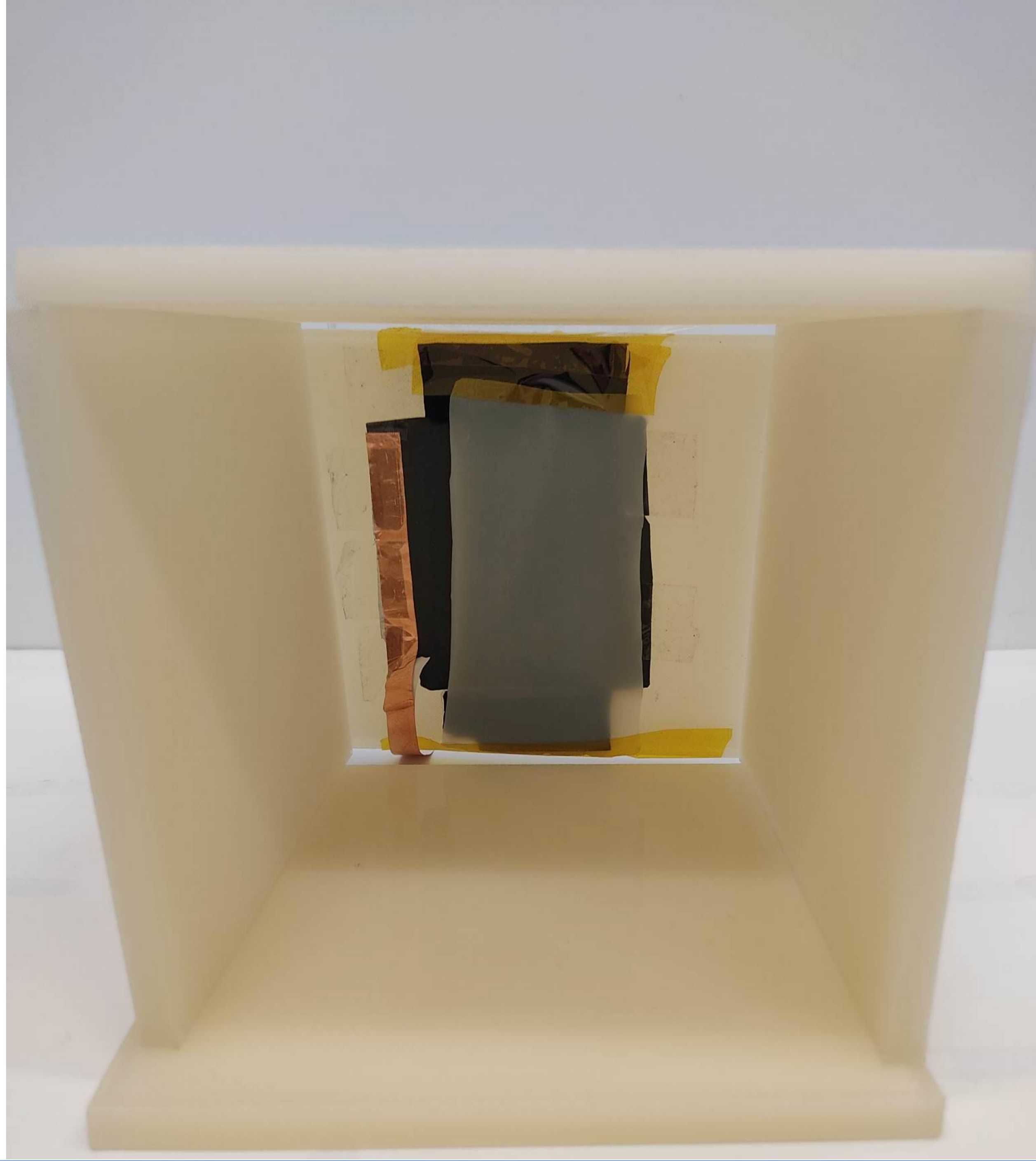
Wind triboelectric nanogenerator based on anti-corrosive metal oxide nanocoatings



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01 Introduction

As the world's population continues to grow, so does the energy demand. This increasing demand has highlighted the urgent need for more sustainable energy generation. Wind triboelectric nanogenerators (WTENGs) are a new, innovative, adaptable green replacement for the more unsustainable energy sources [1,2].

This work aims to utilise the ITFSI's plasma-source technology to further optimise the WTENG by improving its anti-corrosive properties for use in more humid environments (such as Scotland). This is done primarily through the use of physical vapour deposition (PVD), with a particular focus on aluminium oxide (Al_2O_3) and zinc oxide (ZnO).

02 Methodology

A design of experiments (DoE) is first produced for the selected metal oxide on our Plasma Coat deposition system (Figure 1) to test how operational parameters such as **magnetron power**, **plasma power**, **oxygen flow**, and **argon flow,** alter the crystalline structure, morphology and electronic properties of the material.

In this work DoE is also used to evaluate the influence of growth parameters on the output characteristics of WTENG, including open-circuit voltage (V_{oc}), short-circuit current (I_{sc}) and output power (P_{out}).

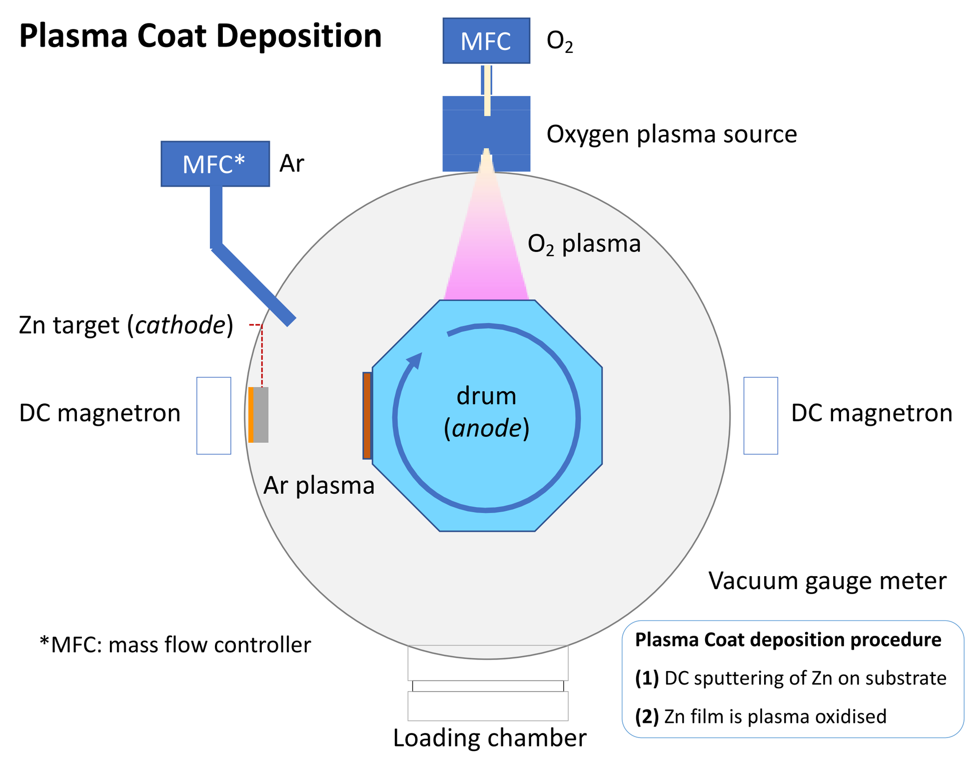
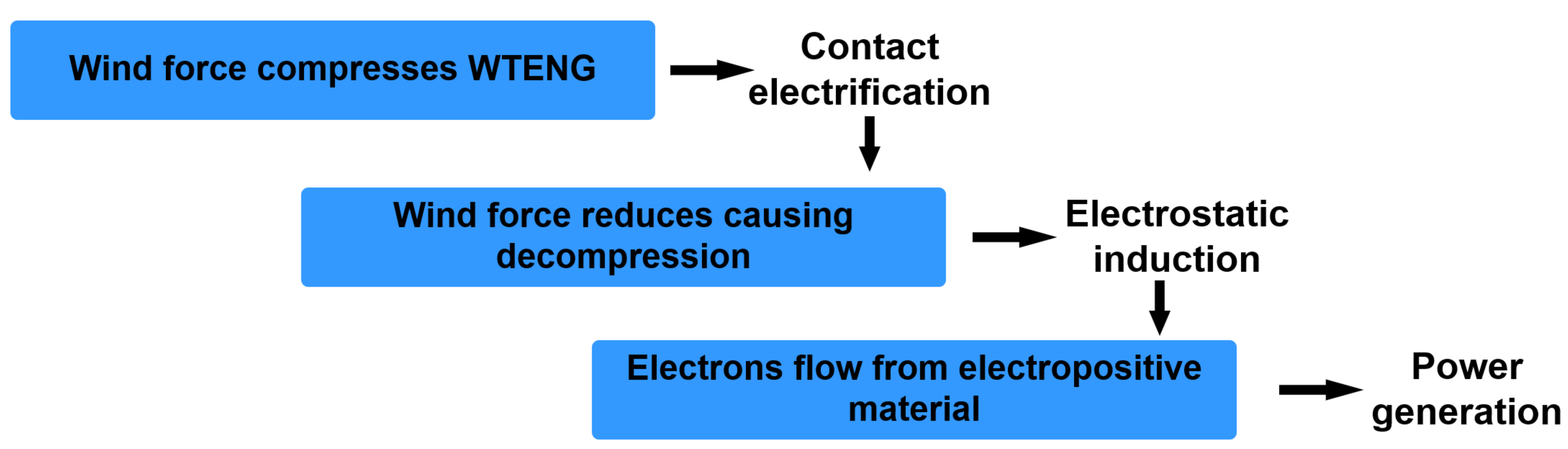


Figure 1: Diagram of the Plasma Coat system.

03 Working principle



Two main themes encapsulate most current research:

- methods for improving the above physical effects (through material choice, surface modifications, etc.), and
- additional desirable characteristics (anti-corrosion, self-healing, etc.).

This research focuses on the latter of those two.

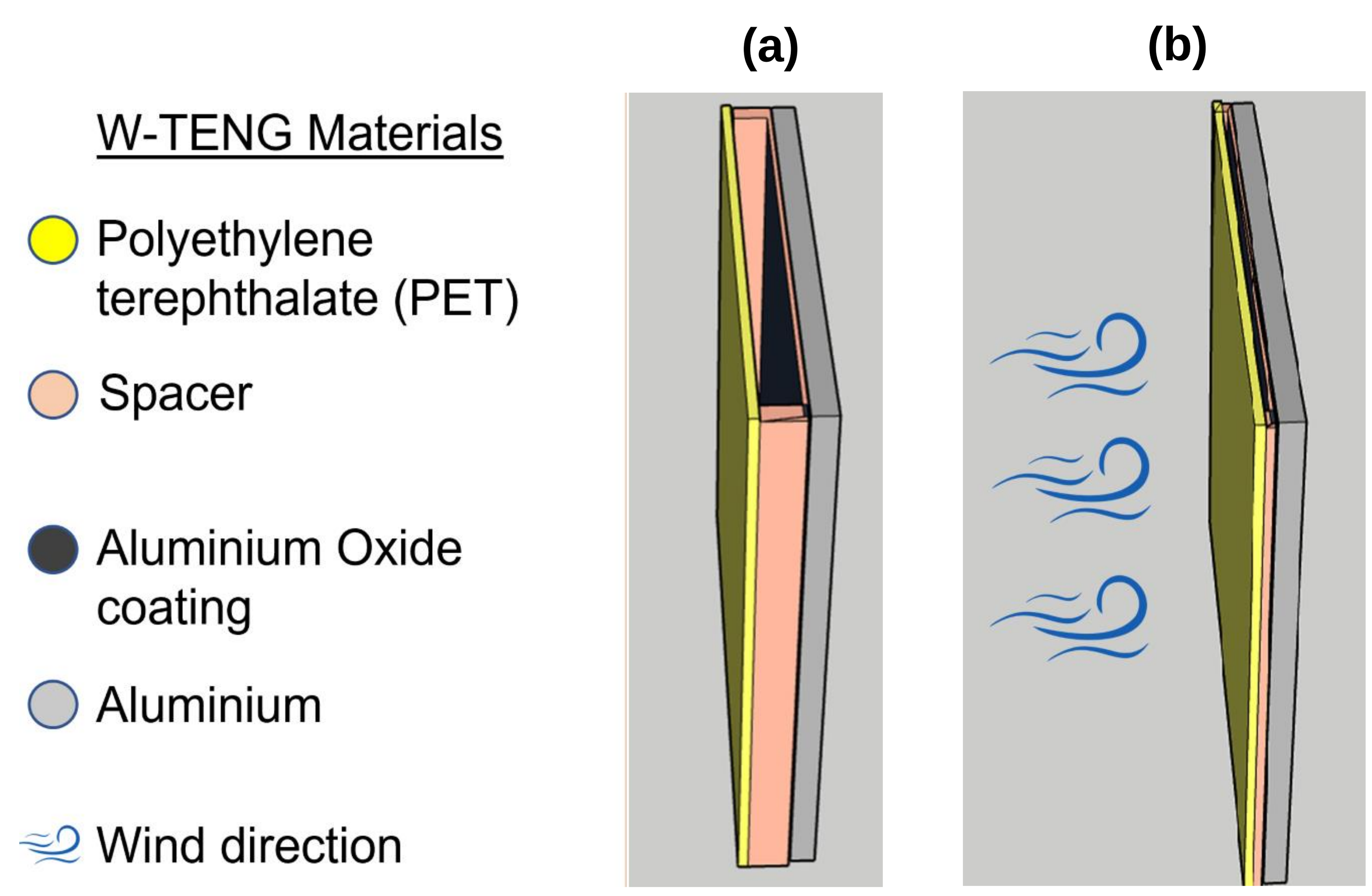


Figure 2: 3D model of WTENG operation, including (a) before and (b) after the wind force compresses the WTENG structure.

04 Results and discussion

WTENG has been tested under a constant wind flow. The cavity used to mount the energy harvesting device has been designed to maximise the vibration of the flexible materials, aiming to increase the number of contact-separation events of two dissimilar tribo materials over time. In this scenario, WTENG output characteristics, including V_{oc}, I_{sc}, and P_{out} have been tested.

Figure 3 presents the results obtained in ZnO-based WTENG, exhibiting an average V_{oc} of **88.5V**. Generally, TENG presents a high internal impedance, requiring a large external resistor to allow the generation of effective electric current. In this work, the best load resistor was 100MΩ. With this resistance, an output voltage and current of **57.80V** and **1.03mA** were obtained, respectively. The device used for these results has an active area of 25.3cm^2. This gives us a performance per area of **23.5 mW/m^2**. These early results show a promising future for WTENG in which energy for low-power systems can be powered by a small portable energy harvesting device.

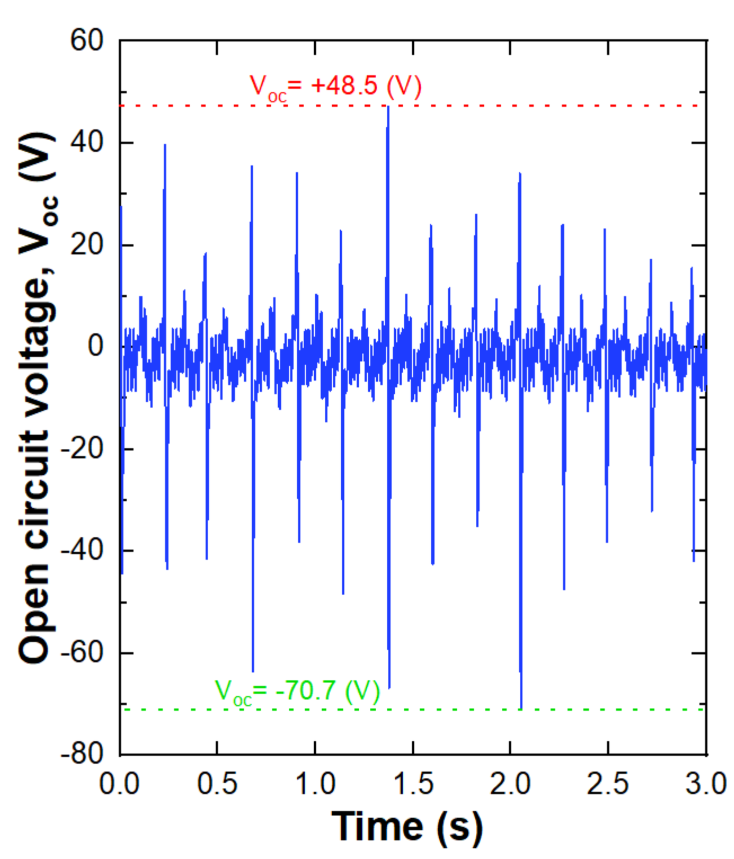


Figure 3: WTENG V_{oc} vs time.

05 Future work

Future work will involve experimenting further with both Al_2O_3 and other metal oxides and finding better ways to integrate the WTENG into devices and applications that would benefit from its energy harvesting. A more optimized wind tunnel would also improve the performance of the WTENG.

Finally, work is being done to develop a power management system to increase the current output from the WTENG. Doing this will allow for devices to be more easily powered by the WTENG.

References

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[2] Walden, R., Kumar, C., Mulvihill, D. M., & Pillai, S. C. (2022). Opportunities and Challenges in Triboelectric Nanogenerator (TENG) based Sustainable Energy Generation Technologies: A Mini-Review. Chemical Engineering Journal Advances, 9, 100237. https://doi.org/10.1016/j.ceja.2021.100237

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