The 8th European Congress on Computational Methods in Applied Sciences and Engineering
ECCOMAS Congress 2022
5-9 June 2022, Oslo, Norway

Computational framework for simulation of triboelectric nanogenerators accounting for surface roughness

Andrei G. Shvarts[1*], Ignatios Athanasiadis[1], Łukasz Kaczmarczyk[1], Charchit Kumar[2], Guanbo Min[2,3], Yang Xu[4], Daniel M. Mulvihill[2], Chris J. Pearce[1]

[1] Glasgow Computational Engineering Centre, James Watt School of Engineering, University of Glasgow, Glasgow, UK
[2] Materials and Manufacturing Research Group, James Watt School of Engineering, University of Glasgow, Glasgow, UK
[3] Bendable Electronics and Sensing Technologies Group, James Watt School of Engineering, University of Glasgow, Glasgow, UK
[4] School of Mechanical Engineering, Hefei University of Technology, Hefei, China
*andrei.shvarts@glasgow.ac.uk, mofem.eng.gla.ac.uk

Keywords: *surface roughness, mechanical contact, electric field, FEM, TENG*

Triboelectric nanogenerators (TENG) transform mechanical energy into electrical energy during cyclic contact between suitably chosen surfaces. They can be used as autonomous harvesters of clean energy from various sources: from human motion to ocean waves [1].

We present a novel framework for coupling mechanical contact and electrostatics equations, permitting simulation of TENG with representative surface roughness. In the contact stage, we solve the contact problem between a dielectric solid (with effective roughness and elastic properties) and a rigid flat. This provides the real contact area morphology which in turn defines the location of surface tribo-charges. In the separation stage, we solve the electrostatics problem in the domain consisting of dielectric layers and the air gap and compute the open-circuit voltage. The development is undertaken in MoFEM [2].

Obtained numerical results [3] show good agreement with both experimental observations and a simplified analytical solution [1]. At the same time, the developed coupled finite-element framework permits extensions accounting for non-linear (e.g. viscoelastic) material behaviour and/or adhesion between contacting layers. Moreover, the proposed framework allows to consider heterogeneous materials and predict the effect of inclusions in the dielectric layers, accelerating the optimisation and design of new TENG.

References

[1] Y. Xu, G. Min, N. Gadegaard, R. Dahiya, and D. M. Mulvihill, "A unified contact force-dependent model for triboelectric nanogenerators accounting for surface roughness," *Nano Energy*, vol. 76, 2020.

[2] L. Kaczmarczyk, Z. Ullah, K. Lewandowski, *et al.*, "Mofem: An open source, parallel finite element library," *The Journal of Open Source Software*, vol. 5, 2020.

[3] A. G. Shvarts, Y. Xu, G. Min, *et al.*, "Finite-element modelling of triboelectric nanogenerators accounting for surface roughness," *Proceedings of UKACM 2021 conference*, 2021. DOI: 10.17028/rd.lboro.14596023.v1.