A dynamic homogenization approach for modelling hybrid piezoelectric nanogenerators

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Maria Laura De Bellis[1], Andrea Bacigalupo[2], Giorgio Zavarise[3]

[1] *University of Chieti-Pescara, INGEO, Viale Pindaro 42, Pescara, Italy*
E-mail:maria.laura.debellis@hotmail.it
[2] *IMT School for Advanced Studies, Piazza S. Francesco 19, 55100 Lucca, Italy*
E-mail:andrea.bacigalupo@imtlucca.it
[3] *Polytechnic University of Turin, DISEG, Corso Duca degli Abruzzi 24, Torino 10129, Italy*
E-mail:giorgio.zavarise@polito.it

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Energy scavenging, from green and sustainable energy resources, is increasingly attracting the attention of researchers and industries in several engineering fields. The main aim is capturing the energy, naturally available in the environment, and converting it into electrical energy. Emerging applications, such as in flexible/strechable micro and nano electronics, biomedical monitoring, wearable technology, micro and nano robotics and extreme technology, require devices of smaller and smaller size and high performances.
In this framework, we investigate hybrid piezoelectric nanogenerators, made up with Zinc oxyde nanorods [1], embedded in a polymeric matrix, and grown on a flexible polymeric support. The ZnO nanorods are arranged in clusters, forming nearly regular distributions, so that periodic topologies can be realistically assumed. It is well established that, in the context of multi-field problems involving complex composite topologies, a very valuable tool is resorting to generalized homogenization approaches [2-4]. Thus, we propose a dynamic multi-field asymptotic homogenization approach, for the static and dynamic characterization of such microstructured periodic devices, [5]. A set of applications is proposed considering nanogenerators based on three different working principles. Both extension and bending nanogenerators are, indeed, analysed, considering either extension along the nanorods axis, or orthogonally to it. The study of the wave propagation is, also, exploited to comprehend the main features of such piezoelectric devices in the dynamic regime.

References

[1] *Wang, Z. L., Song, J., "Piezoelectric nanogenerators based on zinc oxide nanowire arrays". Science,* **312***(5771), 242–246 (2006).*

[2] *Francfort, G. A., "Homogenization and linear thermoelasticity". SIAM Journal on Mathematical Analysis,* **14***(4), 696-708 (1983)*

[3] *Abdessamad, Z., Kostin, I., Panasenko, G., Smyshlyaev, V. P., "Homogenization of thermoviscoelastic KelvinVoigt model". Comptes Rendus Mcanique,* **335***(8), 423-429 (2007).*

[4] *Fantoni, F. Bacigalupo, A., Paggi, M., "Multi-field asymptotic homogenization of thermopiezoelectric materials with periodic microstructure". International Journal of Solids and Structures,* **120***, 31-56 (2017).*

[5] *De Bellis M. L., Bacigalupo A., Zavarise G., "Characterization of hybrid piezoelectric nanogenerators through dynamic asymptotic homogenization", submitted, http://arxiv.org/abs/1902.04010, 2019*