9th European Congress on Computational Methods in Applied Sciences and Engineering (ECCOMAS 2024)
June 03- 07, 2024, Lisbon, Portugal

MECHANICS OF SOFT, MULTIFUNCTIONAL MATERIALS: EXPERIMENT, MODELING AND SIMULATION

TRACK NUMBER 1600

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Key words: Soft materials, smart materials, magnetorheological elastomers, electroactive polymers, hydrogels, light-driven actuations, finite deformations

ABSTRACT

'Can materials act as machines?' is one of the most pressing questions among material scientists and engineers since the last decade of the twentieth century. Machines consisting of a set of materials are usually designed to perform some specific tasks such as generating motion or lifting an object. Hence, one of the most active fields of current research is syntheses, experiments, modelling, and designs of responsive materials that can integrate within machines or act as machines. Responsive materials are smart and innovative substances that can be activated under the application of external or internal stimuli including electric field, magnetic field, pH, light, temperature, humidity or combinations of two or more of them [1]. One of the most promising features of these materials is their ability to undergo large deformations upon the (remote or contactless) application of active fields. Their multifunctional properties make them outstanding candidates for innovative technical applications ranging from large-displacement actuators over smart sensing devices to synthetic soft tissues in flexible

electronics. Most of the smart materials have unique microstructures which can be tuned/optimized to further enhance their properties. In case of magneto- and electro-active composites, these are usually composed of a soft matrix and embedded inclusions. From a theoretical and computational viewpoint, this calls for the development of homogenization schemes to help at conceptualizing customized composite's effective properties [2,3]. Moreover, recent advancements in additive manufacturing (3D printing) provide ample opportunities to intricately design these materials from the micro and nanoscale to "program" their macrostructural response. At the same time, the advance of experimental techniques allowing for precise and reliable validation and testing is paramount.

Thanks to advances in almost all areas of soft multifunctional materials, innovative structures can be designed in the form of thin and slender components with the potential to undergo structural instabilities (i.e., buckling) in certain loading ranges [4,5]. The resulting phenomena could, for example, be harnessed to arrive at very large deformations under rather small applied fields, making materials ready for even more efficient actuation and sensing purposes. The goal of this minisymposium is to bring together researchers from experiment, modeling and simulation in order to discuss recent advancements and new directions in the field. Topics of interest include:

- Electro- magneto-, light-active elastomers
- Responsive gels (hydrogels, ionic polymers, …)
- Liquid crystal elastomers and gels
- Experimental testing and validation
- Constitutive modeling and numerical simulation
- Multiscale approaches and homogenization
- 4D printing of soft smart materials
- Material and structural instabilities
- Materials design of soft solids….

REFERENCES

1. A. K. Bastola, M. Hossain, "A review on magneto-mechanical characterizations of magnetorheological elastomers", Composites Part B. 200: 108348, 2020
2. D. Garcia-Gonzalez, M. Hossain, "A microstructural-based approach to model magneto-viscoelastic materials at finite strains", Int. J. Solids & Structures, 208-209:119-132, 2021
3. E. Polukhov, M.-A. Keip, "Multiscale stability analysis of periodic magnetorheological elastomers", Mech. Mat., 159:103699, 2021
4. Q. Zhang, S. Rudykh, "Magneto-deformation and transverse elastic waves in hard-magnetic soft laminates" Mech. Mat., 169:104325, 2022
5. J. Liu, Y. Yang, M. Li, F. Xu, "A meshfree model for hard-magnetic soft materials", Int. J. Mech. Sci., 108566, 2023