

## PhD position in Mechanics of Solids at University of Parma, Italy

There is 1 fully-funded PhD studentship (3 year bursary) available for a **1st November 2023 start**. A description of the research programme is given below. For further details, contact Prof. Andrea Spagnoli, [spagnoli@unipr.it](mailto:spagnoli@unipr.it), +39 334 6896430. Interested applicants should send a CV to Prof. Spagnoli, and follow this [link](#) to apply. Preferred applicants should hold a degree in Engineering with a major in Solid and Structural Mechanics. **Deadline for application 3rd August 2023.**

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### STRENGTH, DAMAGE AND FRACTURE OF HIGHLY DEFORMABLE POLYMERIC MATERIALS

**Tutor: prof. A. Spagnoli, co-tutor: prof. R. Brighenti**

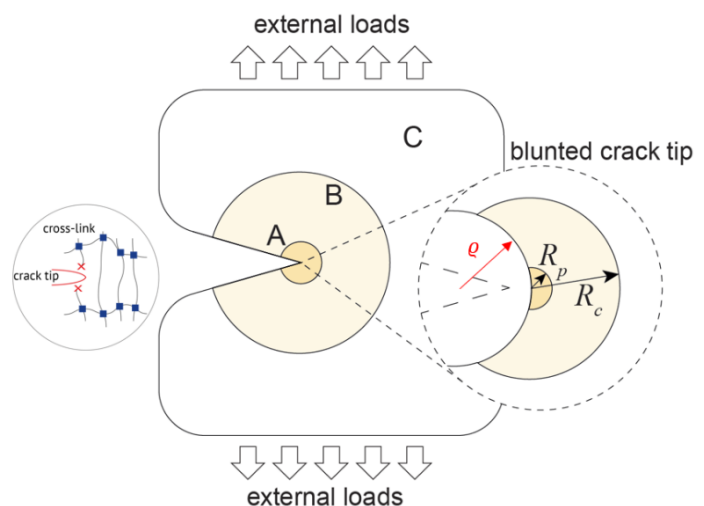
Mechanical response of highly deformable materials, especially polymers, elastomers, foams, gels, biomimicking phantom tissues, is far from being fully understood. In fact, their response under mechanical (stress) or other physical stimuli (temperature, interaction with fluids, etc.) requires to account for a broad range of effects such as large strain, entropic deformation energy, strain rate-related phenomena, hysteresis loops (Mullins effect), coupling with other physics (diffusion of fluids, self-diffusion of material's molecules, heat diffusion, etc.), all of them make modelling this class of materials still an open issue.

Understanding how strength, fracture toughness and all the main material's mechanical parameters are related to its microstructure and to the production process (nowadays often performed by using high-precision modern additive manufacturing technologies) is a crucial task for truly engineered synthesis and building procedures.

Further, the development of physics-based continuum models suitable to be implemented in computational codes, is required for the design of new structures and devices to be used in a broad range of advanced applications, ranging from civil engineering (sensors, deployable structures), to mechanics and biomechanics (soft robots, tunable actuators, wearable devices, robotic surgery).

The aim of the present research topic is to comprehensively study the microstructure-mechanical response relationship of highly deformable polymeric materials, in order to fully understand the underlying damage and failure mechanisms and to define new testing procedures and measurement strategies suitable to properly characterize their mechanical properties. Fracture-related failure mechanisms are studied in the context of remotely applied loading as well as of 'local' actions (e.g. see cutting and puncturing mechanisms).

Solving the above-listed issues will provide an incredibly wide design space, not offered by other traditional materials such as metals and ceramics, enabling the production of architected materials with a controllable and tunable response (materials by design).



#### Relevant papers

Montanari, M., Brighenti, R., Terzano, Spagnoli, A. Puncturing of soft tissues: experimental and fracture mechanics-based study (2023) *Soft Matter* (in press).

Spagnoli, A., Brighenti, R., Montanari, M., Terzano, M. Crack-tip blunting and its implications on fracture of soft materials (2023) *Fatigue and Fracture of Engineering Materials and Structures*, 46 (4), pp. 1627-1637.

Terzano, M., Spagnoli, A., Dini, D., Forte, A.E. Fluid–solid interaction in the rate-dependent failure of brain tissue and biomimicking gels (2021) *Journal of the Mechanical Behavior of Biomedical Materials*, 119, art. no. 104530, .

Spagnoli, A., Brighenti, R., Cosma, M.P., Terzano, M. Fracture in soft elastic materials: Continuum description, molecular aspects and applications (2021) *Advances in Applied Mechanics*, .

Brighenti, R., Cosma, M.P., Marsavina, L., Spagnoli, A., Terzano, M. Laser-based additively manufactured polymers: a review on processes and mechanical models (2021) *Journal of Materials Science*, 56 (2), pp. 961-998.

Terzano, M., Dini, D., Rodriguez y Baena, F., Spagnoli, A., Oldfield, M. An adaptive finite element model for steerable needles (2020) *Biomechanics and Modeling in Mechanobiology*, 19 (5), pp. 1809-1825.

Spagnoli, A., Brighenti, R., Terzano, M., Artoni, F. Cutting resistance of soft materials: Effects of blade inclination and friction (2019) *Theoretical and Applied Fracture Mechanics*, 101, pp. 200-206.

Spagnoli, A., Terzano, M., Brighenti, R., Artoni, F., Ståhle, P. The fracture mechanics in cutting: A comparative study on hard and soft polymeric materials (2018) *International Journal of Mechanical Sciences*, 148, pp. 554-564.

Terzano, M., Spagnoli, A., Ståhle, P. A fracture mechanics model to study indentation cutting (2018) *Fatigue and Fracture of Engineering Materials and Structures*, 41 (4), pp. 821-830.

Vernerey, F. J., Long, R., & Brighenti, R. (2017). A statistically-based continuum theory for polymers with transient networks. *Journal of the Mechanics and Physics of Solids*, 107, 1-20.