UNIVERSITÀ DI PISA

DIPARTIMENTO DI INGEGNERIA DELL'INFORMAZIONE

Dottorato di Ricerca in Ingegneria dell'Informazione

Doctoral Course

"Nanomechanics for Intelligent Materials"

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Short Abstract: The course will be focused on nano-indentation methods for probing material mechanical properties at the micro-scale, with particular reference to soft materials, such as hydrogels and soft tissues [1,2].

First, an overview on material elastic and viscoelastic properties will be provided, presenting the basic mechanical elements (spring, dashpot) and the classical lumped parameter models (Generalised Maxwell Model) typically used to describe material mechanical behavior [3,4]. The focus will be on i) experimental nano-indentation methods to derive both elastic (Oliver-Pharr and Hertz models) and viscoelastic (dynamic nano-indentation and nano-epsilon dot method) properties and ii) data analysis to identify lumped model parameters [1,5–7]. Pros and cons of deriving material viscoelastic properties in the frequency (i.e. dynamic nano-indentation) or in the strain rate (i.e. nano-epsilon dot test) domain will be then discussed, presenting practical examples [3,8]. The course will end with a hands-on lab session dedicated to performing nano-indentation measurements on soft materials.

Course Contents in brief:

1st lesson (seminar, 2h30')

- Introduction to material elastic and viscoelastic properties
- Basic elements (spring, dashpot) and classical lumped models (Generalised Maxwell Model) to describe material mechanical behaviour
- Classical nano-indentation methods to characterise material elastic properties (Oliver-Pharr, Hertz model)

2nd lesson (seminar, 2h30')

- Classical nano-indentation methods to characterise material viscoelastic properties (dynamic nano-indentation, nano-epsilon dot method)
- Pros and cons of deriving material viscoelastic properties in the frequency (i.e. dynamic nano-indentation) or in the strain rate (i.e. nano-epsilon dot test) domain

3rd lesson (lab session, 3h)

- Nano-indentation measurements on soft materials.

Total # of hours: 8

References:

[1] G. Mattei, G. Gruca, N. Rijnveld, A. Ahluwalia, The nano-epsilon dot method for strain rate viscoelastic characterisation of soft biomaterials by spherical nano-indentation, J. Mech. Behav. Biomed. Mater. 50 (2015) 150–159. doi:10.1016/j.jmbbm.2015.06.015.

[2] M.L. Oyen, Nanoindentation of biological and biomimetic materials, Exp. Tech. 37 (2013) 73–87. doi:10.1111/j.1747-1567.2011.00716.x.

[3] G. Mattei, A. Ahluwalia, Sample, testing and analysis variables affecting liver mechanical properties: A review, Acta Biomater. 45 (2016) 60–71. doi:10.1016/j.actbio.2016.08.055.

[4] D. Roylance, Engineering viscoelasticity, Dep. Mater. Sci. Eng. Inst. Technol. Cambridge MA. 2139 (2001) 1–37.

[5] G. Mattei, L. Cacopardo, A. Ahluwalia, Micro-Mechanical Viscoelastic Properties of Crosslinked Hydrogels Using the Nano-Epsilon Dot Method, Materials (Basel). 10 (2017) 889. doi:10.3390/ma10080889.

[6] H. van Hoorn, N.A. Kurniawan, G.H. Koenderink, D. Iannuzzi, Local dynamic mechanical analysis for heterogeneous soft matter using ferrule-top indentation, Soft Matter. 12 (2016) 3066–3073. doi:10.1039/C6SM00300A.

[7] M.L. Oyen, R.F. Cook, A practical guide for analysis of nanoindentation data, J. Mech. Behav. Biomed. Mater. 2 (2009) 396–407. doi:10.1016/j.jmbbm.2008.10.002.

[8] G. Mattei, A. Tirella, G. Gallone, A. Ahluwalia, Viscoelastic characterisation of pig liver in unconfined compression, J. Biomech. 47 (2014) 2641–2646. doi:10.1016/j.jbiomech.2014.05.017.

CV of the Teacher

Please see attachment.

Room and Schedule

Room: *Aula Riunioni del Dipartimento di Ingegneria dell'Informazione, Via G. Caruso 16, Pisa – Ground Floor*

Schedule:

1st lesson: 10 Sep 2018 / 9.00 – 11.30 a.m.

2nd lesson: 12 Sep 2018 / 9.00 – 11.30 a.m.

3rd lesson: 17 Sep 2018 / **14.30 – 17.30**