‘Stressed out’ – Opto-Biomechatronics Systems engineered for Soft Tissue Structure-Function Studies

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Tissue/organ function is markedly prone to architectural plasticity and dynamic changes that occur in health, disease and aging. This ‘Structure-Function’ dogma is a well-recognised concept, however, to directly correlate these cues requires (i) advanced optical technologies to resolve tissue architectural patterns, as well as (ii) new biomechatronics feeds to either test for tissue biomechanics or to mechanically condition tissues. Structure, stability, mechanics - they are all interlinked material aspects of biological tissues but most metrologies are still designed to only assess either aspect separately. To bring together structure and mechanics, we have conceived and engineered novel imaging and pattern analysis modalities in conjunction with biomechatronics systems to mechanically stimulate or condition cells and tissues in 1D (e.g., *MyoRobot*[1,2], *MechaMorph*[3]), 2D (e.g., *IsoStretcher*[4,5], *MultiStretcher*[6]) and 3D (*PiezoGRIN*[7] pressure vessel). We combine those with label-free multiphoton imaging, i.e. *Second Harmonic Generation* (SHG) and fluorescence microscopy, to derive specific tissue patterns, e.g., to monitor tissue remodelling. In this talk, a selection of morphometry concepts in 3D and tissue conditioning/biomechatronics systems are presented with applications from disease models and tissue engineering.

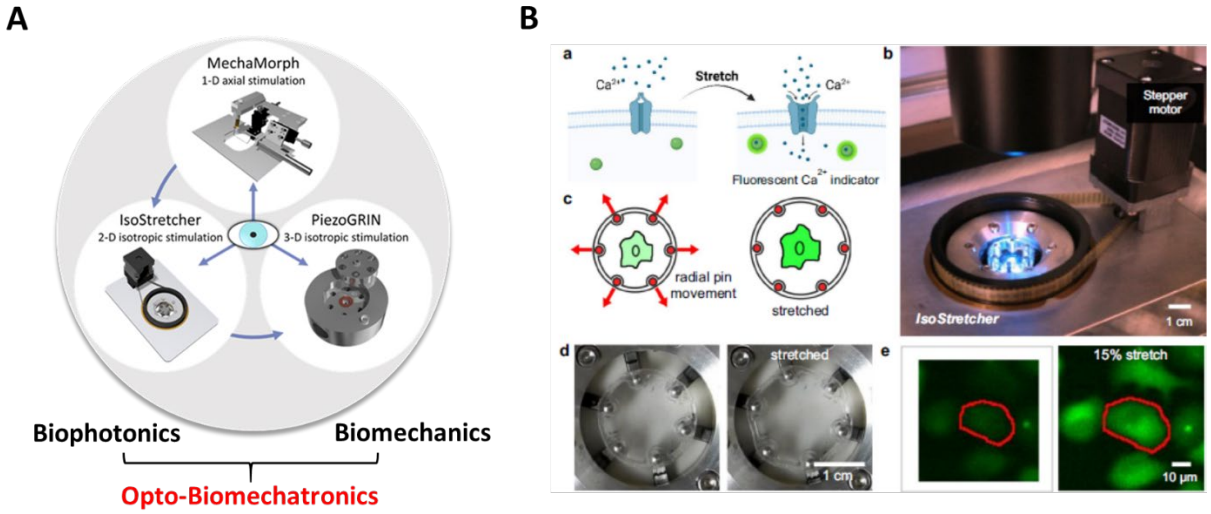

Figure 1 **Opto-Biomechatronics concept and selected metrologies: A, c**ombining biomechanics and biophotonics metrologies in a holistic Opto-Biomechatronics approach to cover multi-dimensional cell/tissue analyses of structure and function. **B,** example metrology *IsoStretcher* for applying isotropic strain to cells and simultaneous Ca^{2+} imaging of mechanosensitive signalling[5].

References:

[1] Haug M, et al. *Biosens Bioelectron* **2019**, 138, 111284. [2] Haug M et al. *Biosens Bioelectron* **2018**, *102*, 589-599. [3] Schneidereit D et al. *light Sci Appl* **2018**, *7*, 79. [4] Schürmann S et al. *Biosens Bioelectron* **2016**, *81*, 363-372. [5] Merten AL et al. *Cell Mol Life Sci* **2024**, *81(1)*, 140. [6] Schoofs H et al. *Nature* **2025**, *641*, 465-475. [7] Schneidereit D et al. *Adv Sci* **2018**, 6(4), 1801453.