Design and implementation of a strain- and stress-controlled linear rheometer for advanced rheomicroscopy applications

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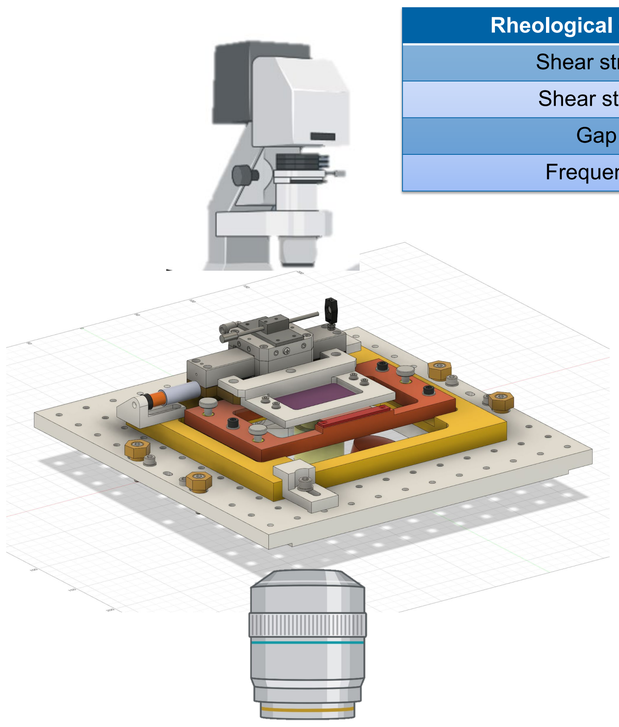
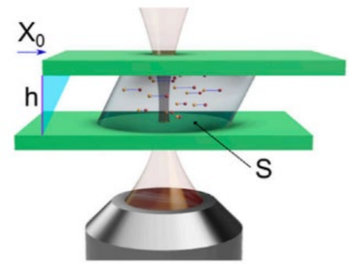
Take home message

We built a cost-effective, precise shear cell for soft materials that can be mounted on any microscope to correlate rheological spectra, mesoscopic shear profiles, and microscopic dynamics.

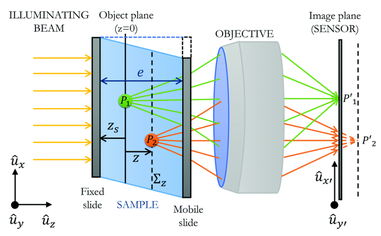
Setup and Technique

Rheological quantity	Accessible range
Shear stress	1 Pa - 10^4 Pa
Shear strain	1 % - 10^3 %
Gap	100 um - 1 mm
Frequency	0.001 Hz – 10 Hz



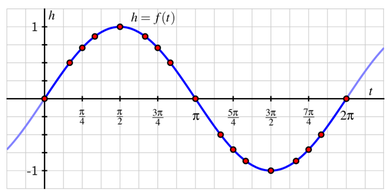


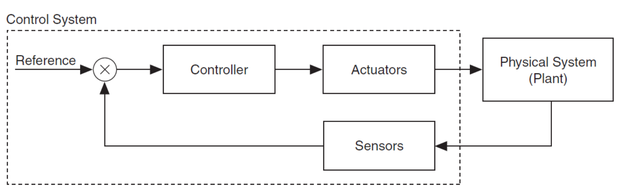
S. Villa et al, Frontiers in Physics , 2022



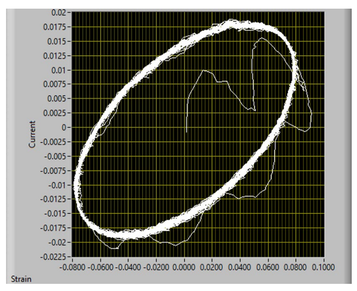
S. Aime, *Soft Matter*, 2019

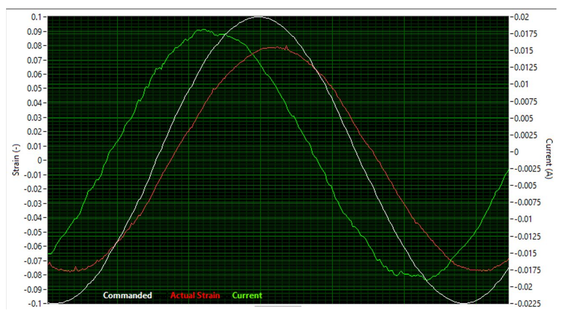
Strain control feedback loop



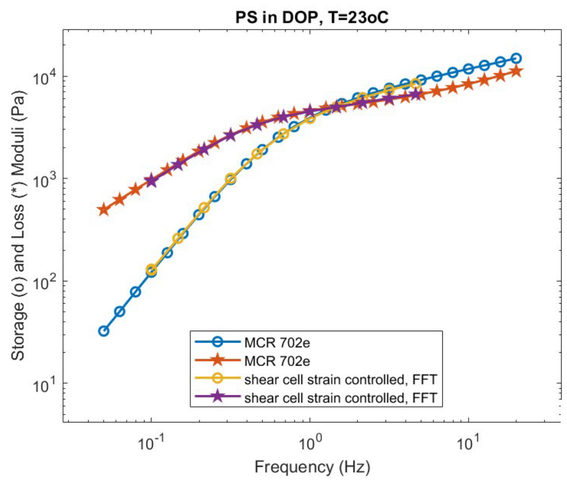


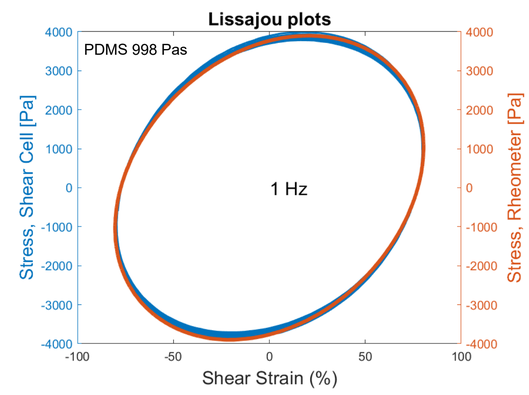
Live (Raw) Data during experiment

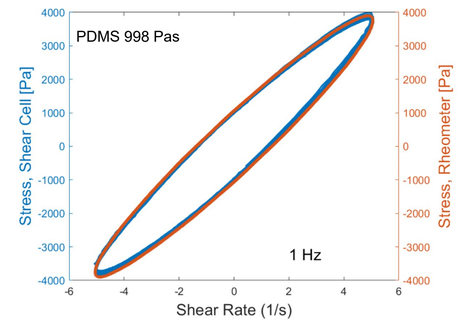


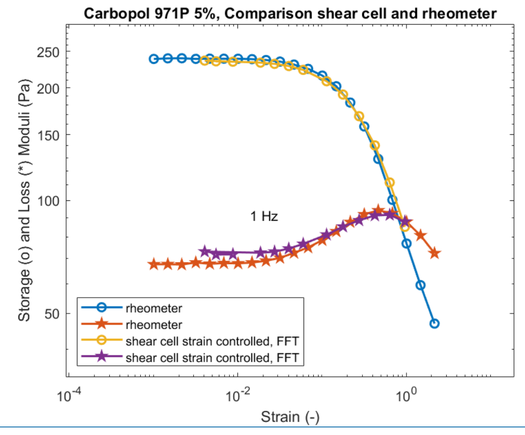


Results- Rheology

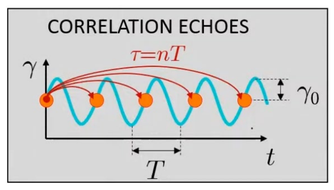


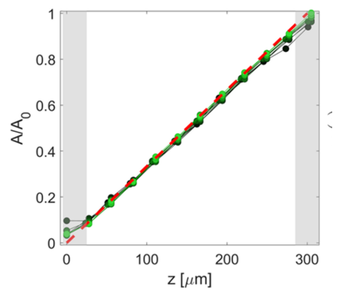


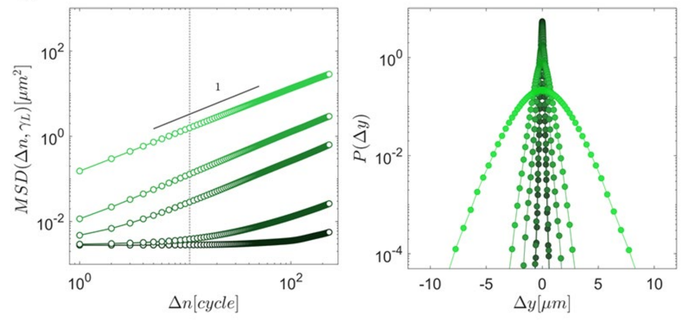




Results- Microscopy







See also:
Edera et al., *Yielding under the microscope: a multi-scale perspective on brittle and ductile behaviors in oscillatory shear*, arXiv, 2024

Conclusions

- We built a simple but robust strain-controlled shear cell
- The quality of the rheological data is equivalent to the one collected with a commercial rheometer
- Imaging coupled with rheology allows us to study processes (flow instabilities, microscopic dynamics) occurring at different levels within the sample
- We can measure the true, local strain in the presence of -shear induced- flow non-idealities

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References:

[1] Villa et al. *Frontiers in Physics*, 2022
[2] Aime et al. *Review of Scientific Instruments*, 2016
[3] Edera et al., Yielding under the microscope: a multi-scale perspective on brittle and ductile behaviors in oscillatory shear, arXiv, 2024