MECHANICAL DEFORMATIONS IN A GRAPHENE-REINFORCED CELLULOSE SAMPLE

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ABSTRACT

In this work, the interferometric technique of ESPSI (Electronic Speckle Pattern Shearing Interferometry, or Shearography) was adapted for the surface strain measurement along two orthogonal axes due to sensibility in-plane and out-of-plane. The experimental setup and approach for estimating the strain fields was validated using a membrane based on polylactic acid reinforced with cellulose microcrystalline as sample with and without graphene.

EXPRESSIONS FOR MATERIAL MECHANICS

$$\sigma = \frac{F}{A} \quad (1)$$

$$\varepsilon = \frac{L_f - L}{L} \quad (2)$$

$$Y = \frac{\sigma}{\varepsilon} \quad (3)$$

EXPRESSIONS FOR SHEAROGRAPHY

$$I(x,y) = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos(\Delta\phi) \quad (4)$$

$$\delta_1 = \frac{2\pi}{\lambda}\cdot\left[sin\theta \frac{\partial d_x(x,y)}{\partial x} + (1+\cos\theta)\frac{\partial d_z(x,y)}{\partial x}\right]\Delta x \quad (5)$$

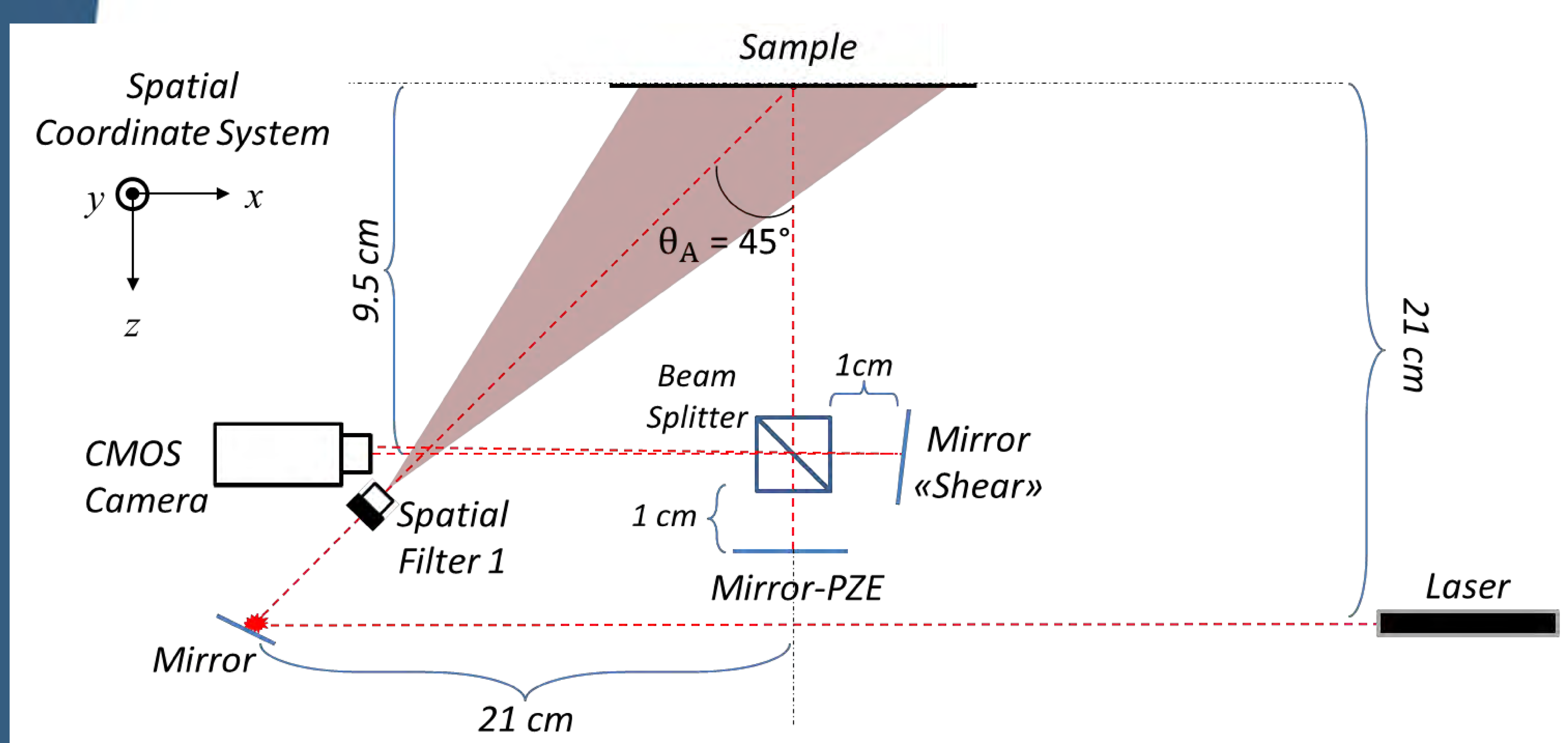

Figure 1. Optical system geometry with illumination from point "A".

$$\delta_2 = \frac{2\pi}{\lambda}\cdot\left[-sin\theta \frac{\partial d_x(x,y)}{\partial x} + (1+\cos\theta)\frac{\partial d_z(x,y)}{\partial x}\right]\Delta x \quad (6)$$

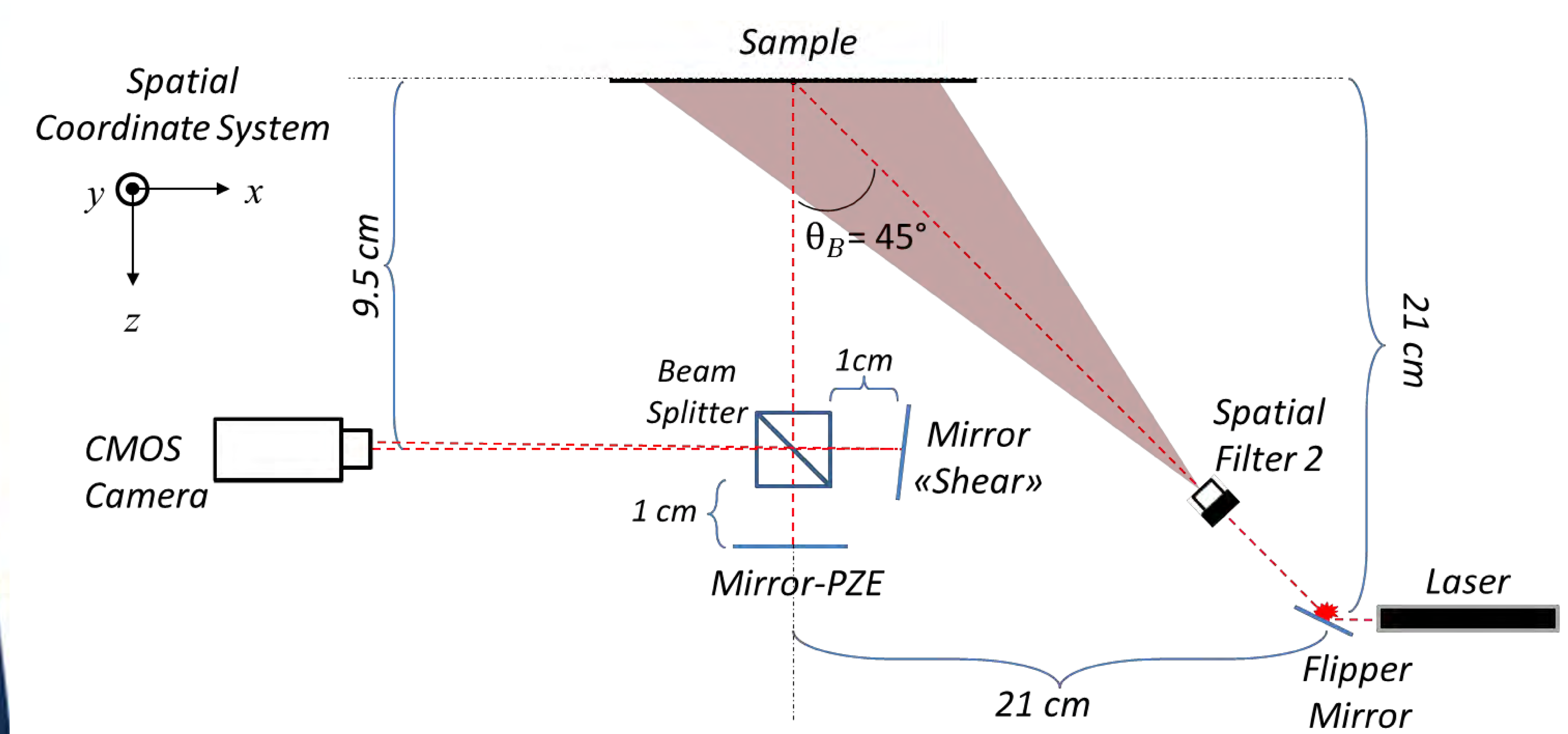

Figure 2. Optical system geometry with illumination from point "B".

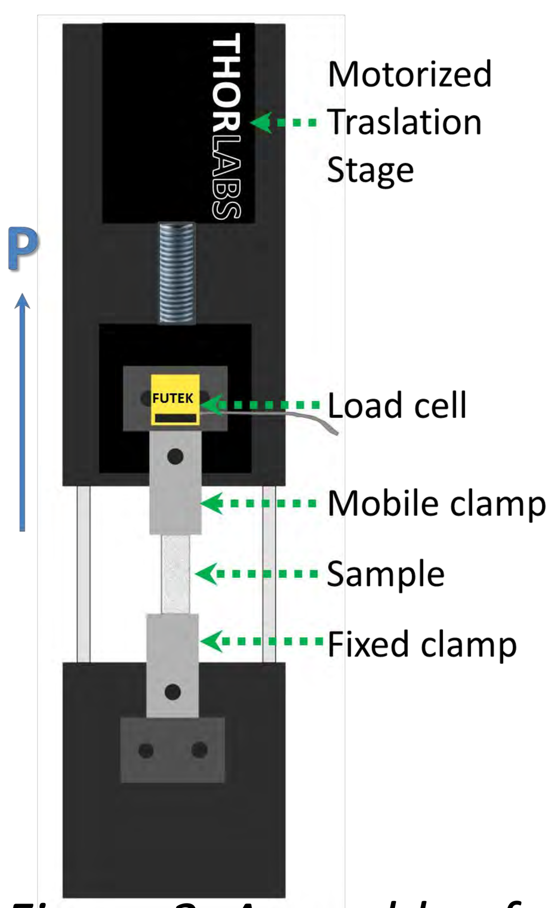

Figure 3. Assemble of local testing machine with sample to be tested (front view, vertical orientation).

EXPERIMENTAL RESULTS

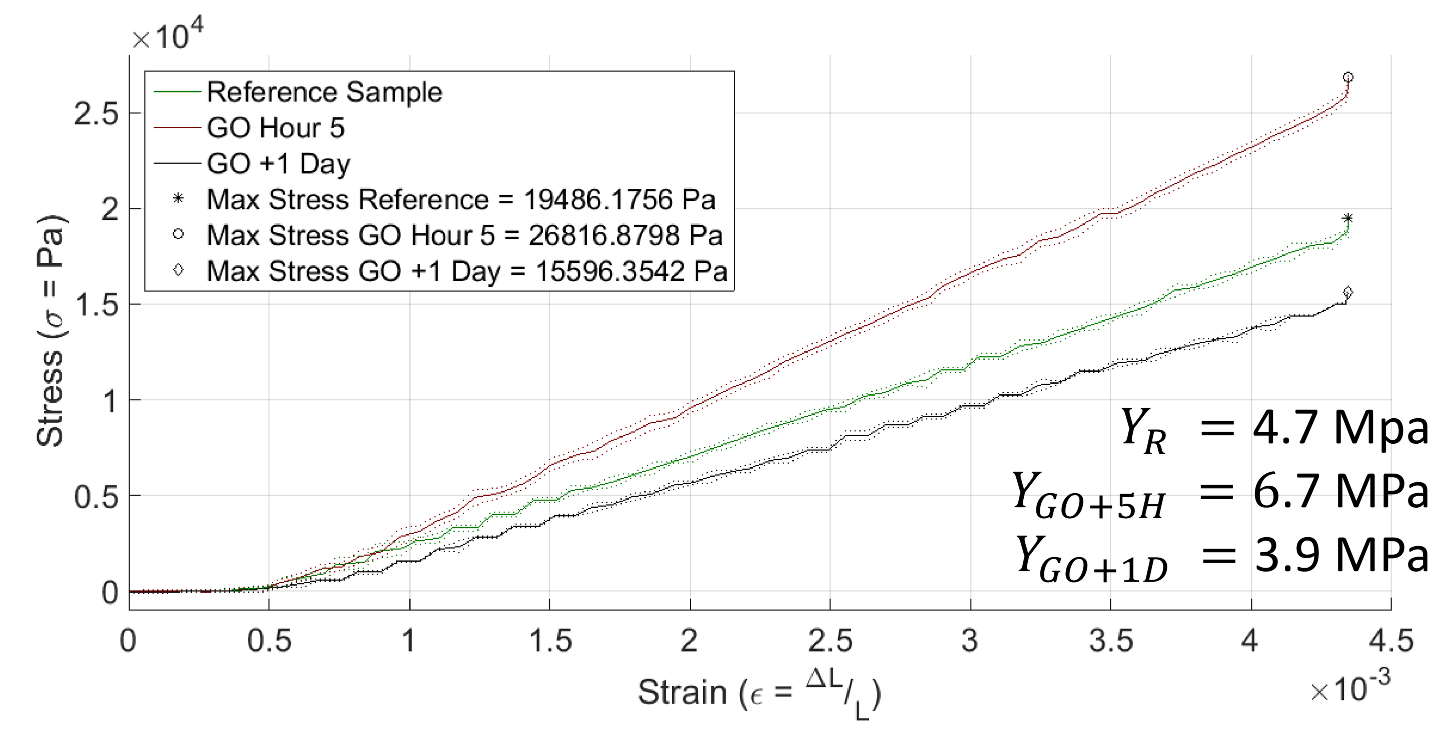

Figure 4. Temporal monitoring stress-strain curves characteristics of a PLA sample with a reinforcement of graphene oxide (GO).

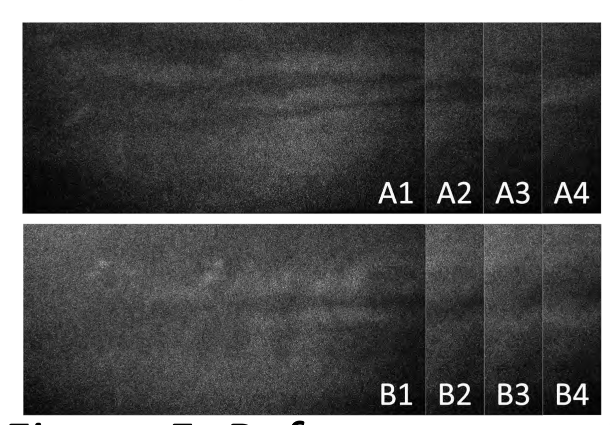

Figure 5. Reference sample:
a) Interferograms for beam "A"
b) Interferograms for beam "B".

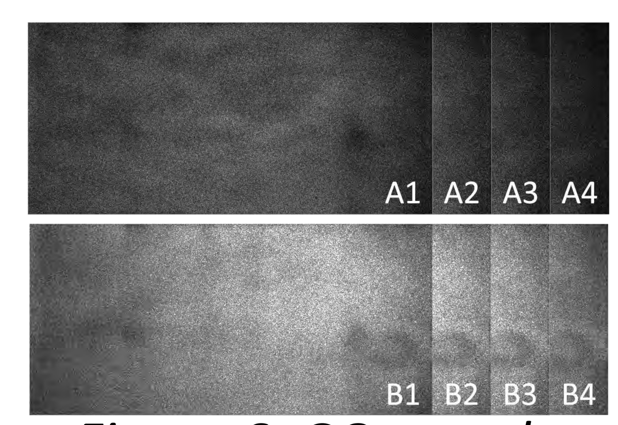

Figure 6. GO sample:
a) Interferograms for beam "A"
b) Interferograms for beam "B".

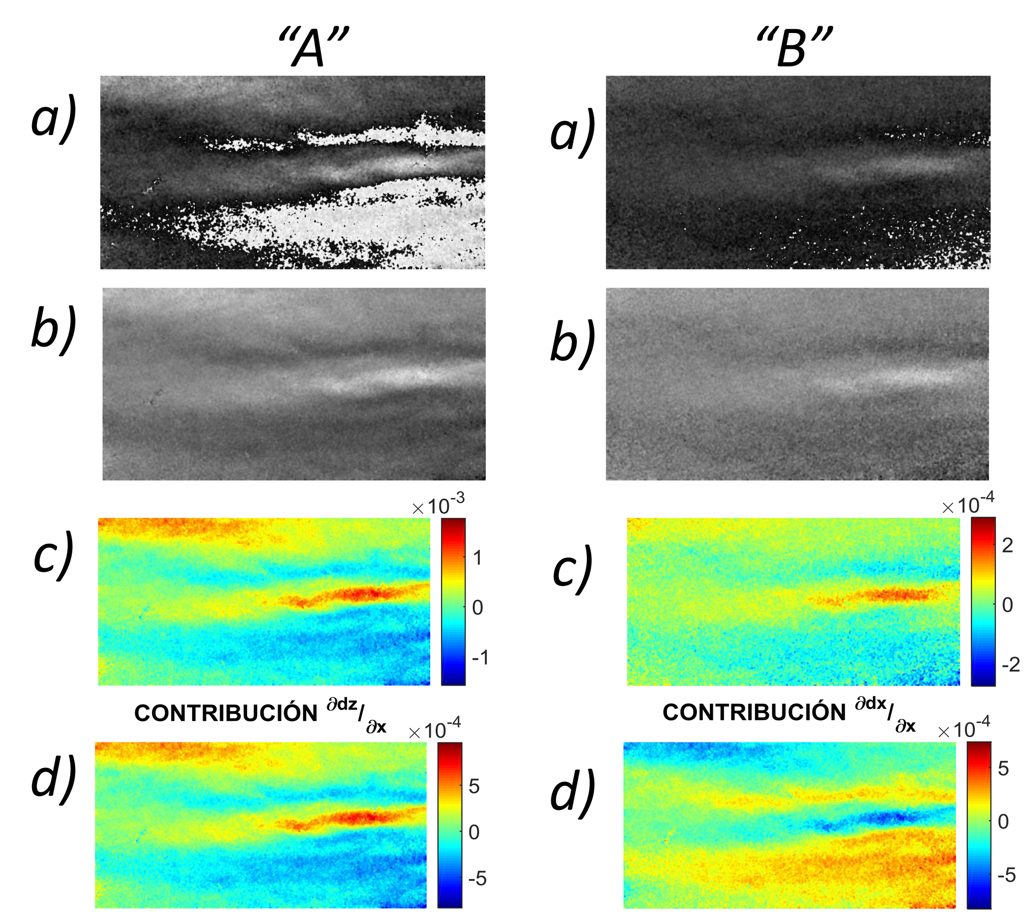

Figure 7. Reference sample, for illumination "A" and "B": a) Wrapped phases b) Unwrapped phases c) Strain maps d) Contribution maps.

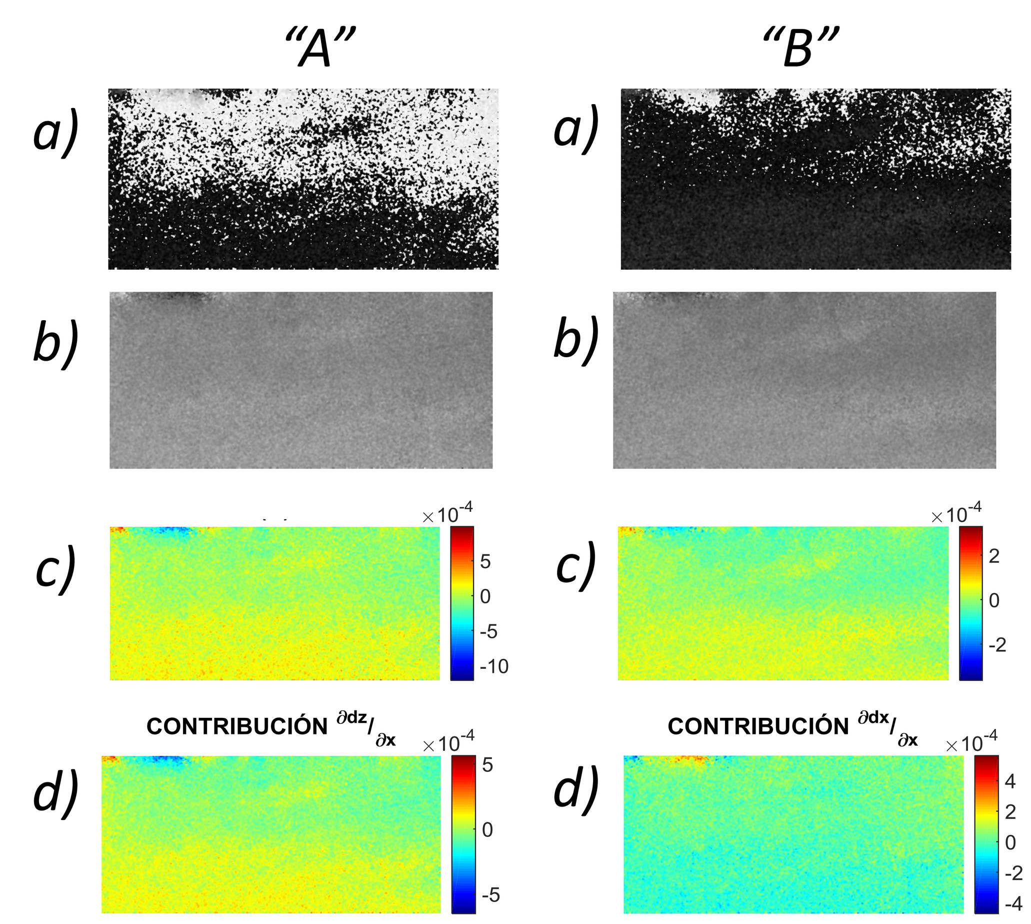

Figure 8. GO sample, for illumination "A" and "B": a) Wrapped phases b) Unwrapped phases c) Strain maps d) Contribution maps.

CONCLUSIONS

- GO reinforcement was considered because graphene is currently the most resistant material known (with a Young's ~1TPa module); however, the reinforcement shown by the material is only temporal, to give continuity to this proposal we suggest the possibility of adding the reinforcement with graphite material changing the chemical composition of the base matrix.
- It is important to emphasize that the optical test does not replace the existing standardized mechanical tests; it only allows us to make a two-dimensional deformation analysis.

REFERENCES: Viotti et al. 2014, Sirohi et al. 1999, Hariharan et al. 2003, Kreis et al. 2005, Gaitán et al. 2018, Hibbeler et al. 2011, Barzegar et al. 2015, Moayeri et al. 2015