

Volume variation after femtosecond laser exposure in fused silica in two regimes

Citation for published version (APA):

Champion, A., & Bellouard, Y. J. (2013). *Volume variation after femtosecond laser exposure in fused silica in two regimes*. Poster session presented at Mate Poster Award 2013 : 18th Annual Poster Contest.

Document status and date:

Published: 01/01/2013

Document Version:

Accepted manuscript including changes made at the peer-review stage

Please check the document version of this publication:

- A submitted manuscript is the version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher's website.
- The final author version and the galley proof are versions of the publication after peer review.
- The final published version features the final layout of the paper including the volume, issue and page numbers.

[Link to publication](#)

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal.

If the publication is distributed under the terms of Article 25fa of the Dutch Copyright Act, indicated by the "Taverne" license above, please follow below link for the End User Agreement:

www.tue.nl/taverne

Take down policy

If you believe that this document breaches copyright please contact us at:

openaccess@tue.nl

providing details and we will investigate your claim.

Volume variation after femtosecond laser exposure in fused silica in two regimes.

A. Champion, Y. Bellouard

Eindhoven University of Technology



Introduction

Femtosecond lasers can be used for producing integrated microsystems in fused silica. The laser is not used for ablating materials but rather for modifying their structure.

Problem statement

Femtosecond laser exposure of fused silica below the ablation threshold leads to two types of modifications: homogeneous modifications and self-organized nano-scale gratings [1-3].

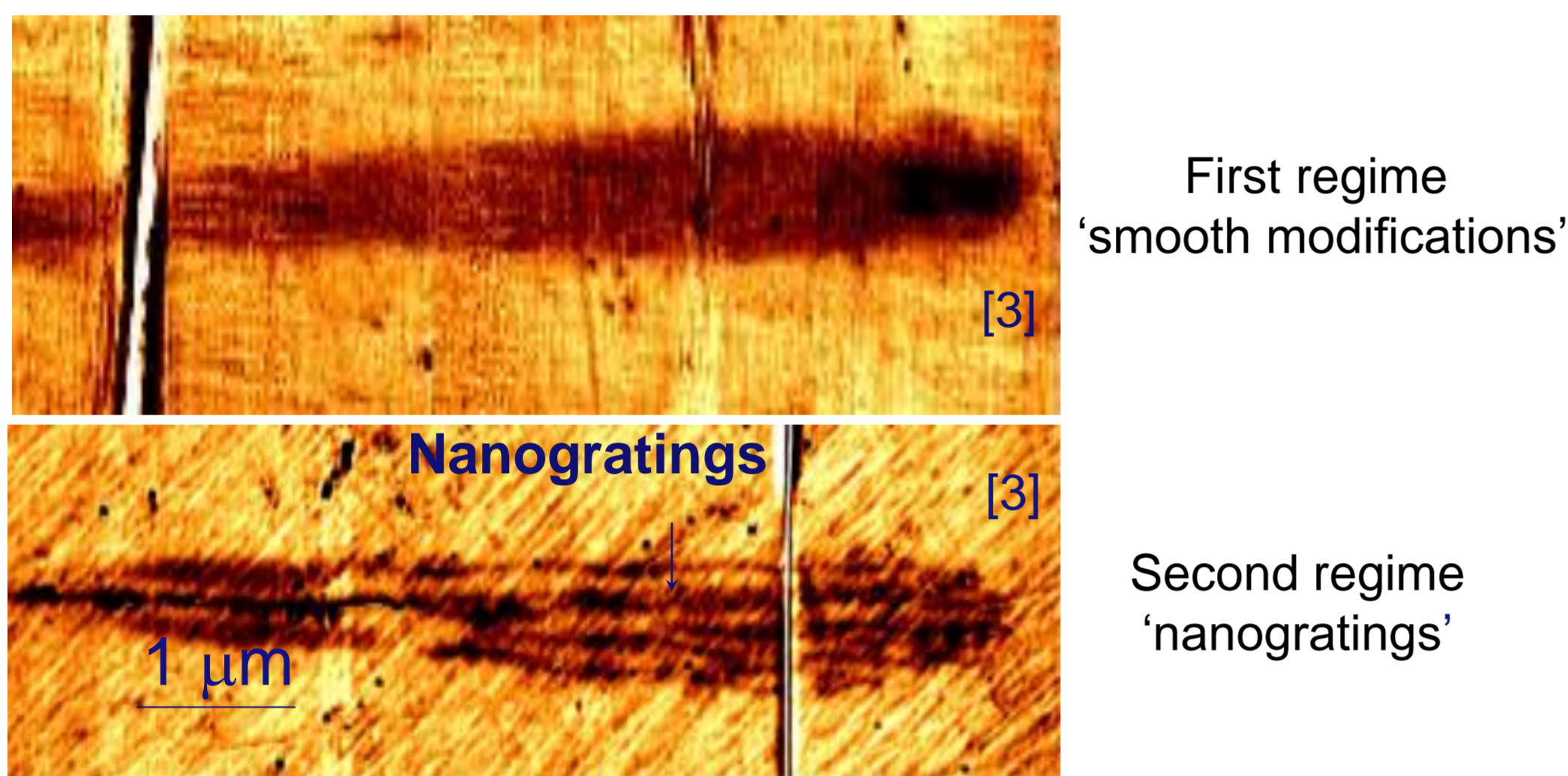


Figure 1: Atomic Force Microscope (SThM) image of transverse cut showing morphologies of laser affected zones.

In this research, we investigate volume variations associated with femtosecond laser exposure in fused silica.

Measurement method working principle

Fused silica cantilevers are used to measure volume changes resulting from partial femtosecond laser irradiations by monitoring their deflections (see Figure 2).

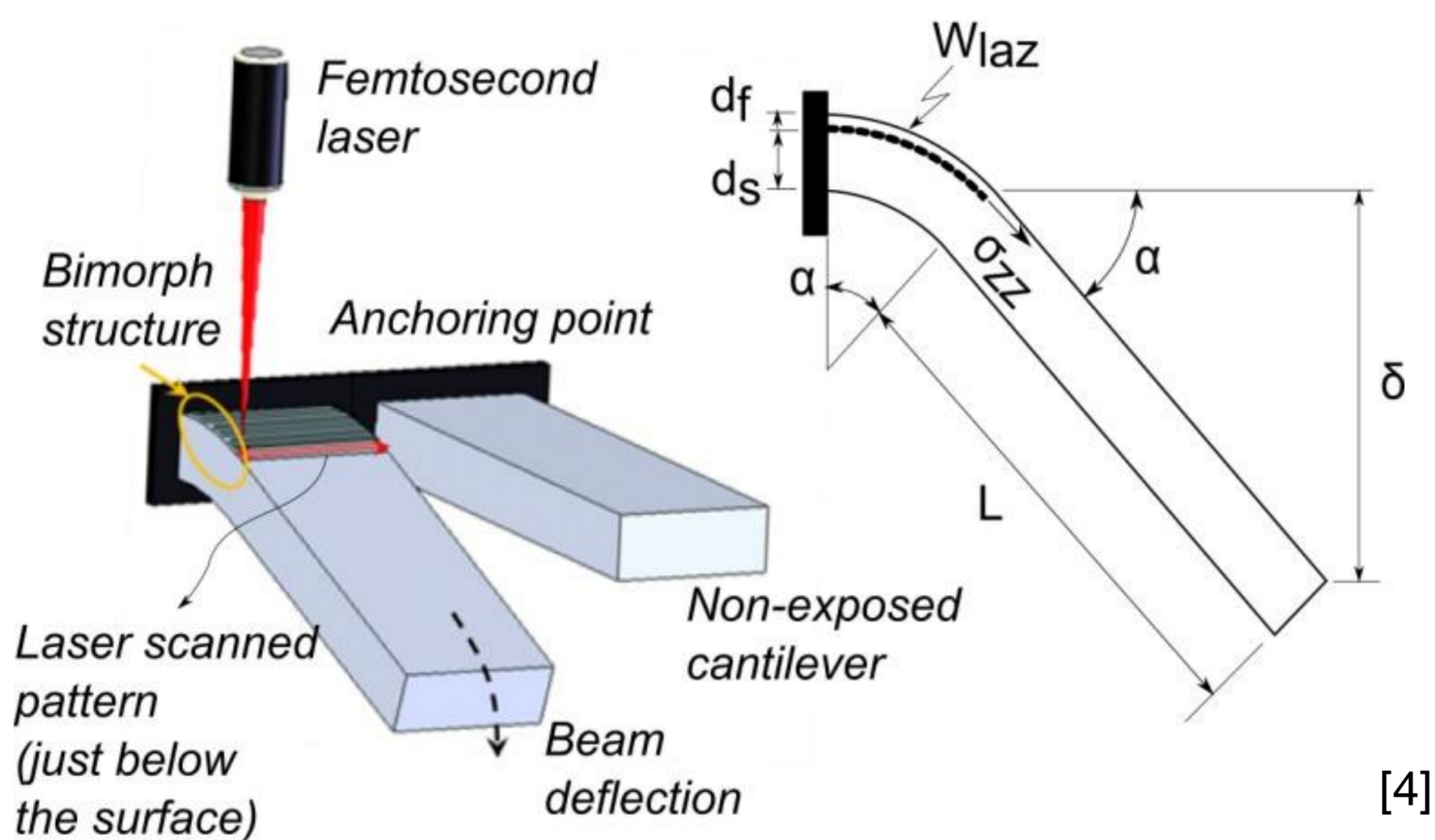


Figure 2: Measurement method principle: local volume variations induced by laser exposure on a top layer of a cantilever causes the cantilever to bend.

From the measured deflections, we calculate the volume expansion resulting from laser exposure and, using Stoney equation as a first approximation, we estimate the stress in the laser affected zone.

$$\varepsilon(\delta) \approx \left(\frac{d_s}{2w_{laz}} \right) \frac{\delta}{L}, \quad \sigma_{zz}(\delta) \approx \left[\frac{E_s d_s^2}{6w_{laz} (1-\nu^2) d_f} \right] \frac{\delta}{L}$$

Experimental details and results

A femtosecond laser providing 160 fs pulse duration at 100 kHz is used to expose the cantilever's bases. Pulse energies span from 180 nJ to 300 nJ. Constant writing speed (10 mm/s) are used. An example of a set of cantilevers is shown Figure 3.

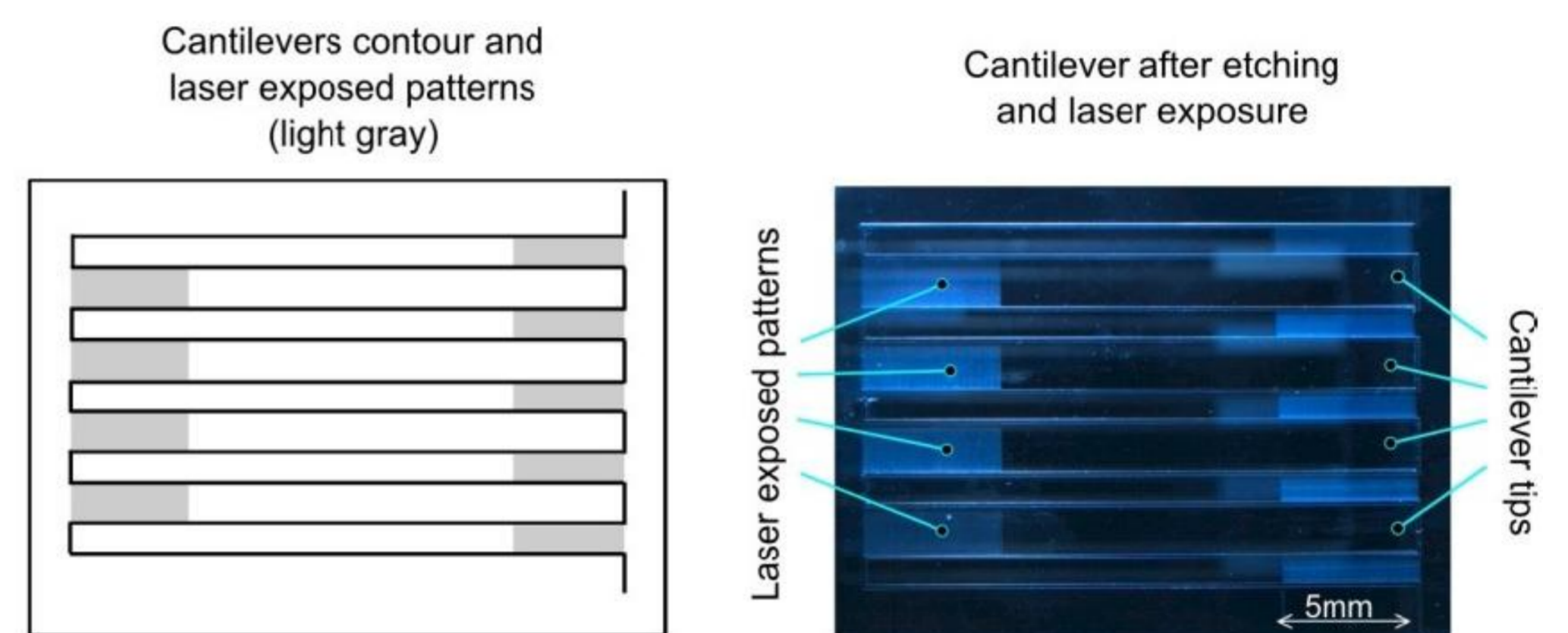


Figure 3: Fused silica cantilever schematics and optical micro-scope image after exposure.

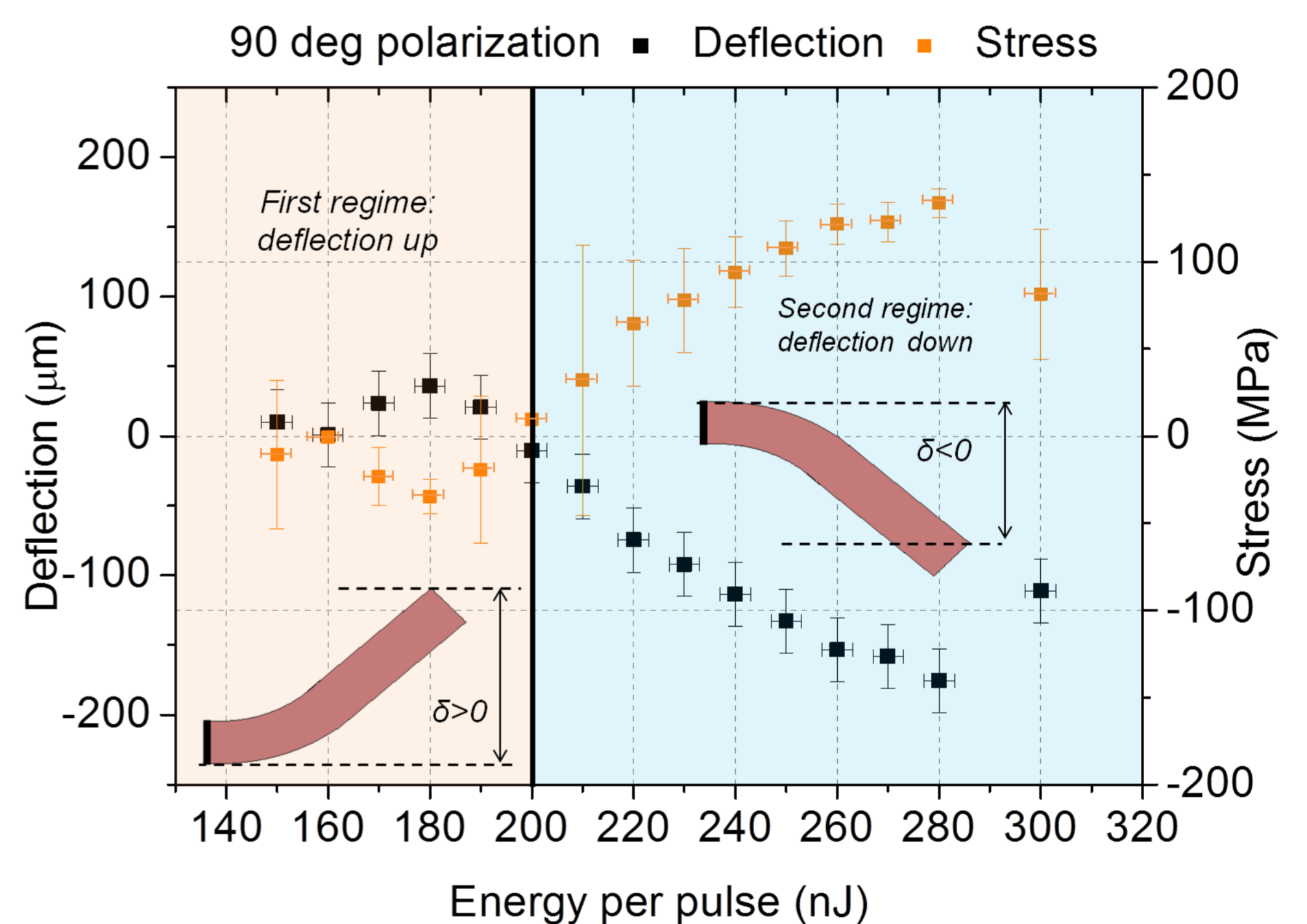


Figure 4: Measure deflections and calculated stress levels as a function of pulse energy.

Interestingly, we observe opposite behaviors between both laser exposure regimes. A densification in the low-energy regime and a volume expansion at higher pulse energies.

Conclusion

Femtosecond laser exposure with pulses shorter than 200 fs induces densification at low pulse energies and a volume expansion at higher levels. These observations are important for identifying the exposure parameters where increased refractive index and integrated optics can be achieved.

References

- [1] C. Hnatovsky *et al.*, Appl. Phys. Lett. **87**, 14104-14106 (2005).
- [2] Y. Shimotsuma *et al.*, Phys Rev. Lett. **91**, 247705 (2003).
- [3] Y. Bellouard *et al.*, Opt. Express **16**, 19520-19534 (2008).
- [4] A. Champion *et al.*, Opt. Mater. Express **2**, 789-798 (2012).