



UNIVERSITY OF LEEDS

This is a repository copy of *Surface Functionalization of Glass Using Femtosecond Laser-Induced Plasma*.

White Rose Research Online URL for this paper:

<https://eprints.whiterose.ac.uk/223368/>

Version: Accepted Version

Proceedings Paper:

Jose, G. orcid.org/0000-0001-9856-6755, Pal, P., Mathieson, R. et al. (1 more author) (2024) Surface Functionalization of Glass Using Femtosecond Laser-Induced Plasma. In: Proceedings CLEO 2024. CLEO: Applications and Technology 2024, 05-10 May 2024, Charlotte, North Carolina United States. Conference on Lasers & Electro-Optics (AM2C.4). Optica Publishing Group, Washington D. C. ISBN 978-1-957171-39-5

https://doi.org/10.1364/cleo_at.2024.am2c.4

© 2024 Optica Publishing Group. One print or electronic copy may be made for personal use only. Systematic reproduction and distribution, duplication of any material in this paper for a fee or for commercial purposes, or modifications of the content of this paper are prohibited.

Reuse

Items deposited in White Rose Research Online are protected by copyright, with all rights reserved unless indicated otherwise. They may be downloaded and/or printed for private study, or other acts as permitted by national copyright laws. The publisher or other rights holders may allow further reproduction and re-use of the full text version. This is indicated by the licence information on the White Rose Research Online record for the item.

Takedown

If you consider content in White Rose Research Online to be in breach of UK law, please notify us by emailing eprints@whiterose.ac.uk including the URL of the record and the reason for the withdrawal request.



eprints@whiterose.ac.uk
<https://eprints.whiterose.ac.uk/>

Surface Functionalization of Glass Using Femtosecond Laser-Induced Plasma

Gin Jose, Paramita Pal, Robert Mathieson, Eric Kumi-Barimah

School of Chemical and Process Engineering, University of Leeds, Leeds, LS2 9JT, United Kingdom

Author e-mail address: g.jose@leeds.ac.uk

Abstract: Femtosecond laser-induced plasma of tellurite-based glasses is used to modify structurally the surface of silicate glasses and silica-on-silicon to engineer optical and photonic components. The refractive index, doping, mechanical strength, and color can be altered using the methodology.

Here we report the recent advances made in the field of ultrafast laser plasma doping (ULPD) method to modify the surface of silica and silicate glasses, and silica-on-silicon. Since first reported in CLEO 2012 [1] the ULPD has been developed for a number of applications. Using a Ti-Sapphire amplified femtosecond laser (pulse duration 100 fs, repetition rate) silica and silica-on-silicon were doped with Er^{3+} ions [2-4]. Optical waveguiding by controlling the depth of doping and refractive index increase has been achieved by laser and process parameters. The highest doping in silica is demonstrated with high calculated gain per unit length and low losses to fabricate waveguide amplifiers [6]. Surface doped materials also demonstrated using fs-laser at 10 kHz and higher repetition rate lasers with pulse durations of 45 fs and < 290 fs using different laser systems. The doping process essentially involve deposition of tellurite based glasses with required dopant on a silica based substrate at an elevated temperature below their glass transition temperature. Here we also report the use of this methodology to strengthen glasses as well as to color them. Figure 1(a) shows an example of a doped layer formed within silica glass substrate. In Fig. 1(b) silicate glass with induced dark blue color produced by the ULPD method is shown. Figure 1(c) represents the refractive index profile of a Er^{3+} -ions doped waveguide formed on silica with a surface refractive index of 1.61 (@633nm) and waveguide thickness of $\sim 3 \mu\text{m}$. In the talk an overview of the process with all the recent application developments will be presented.

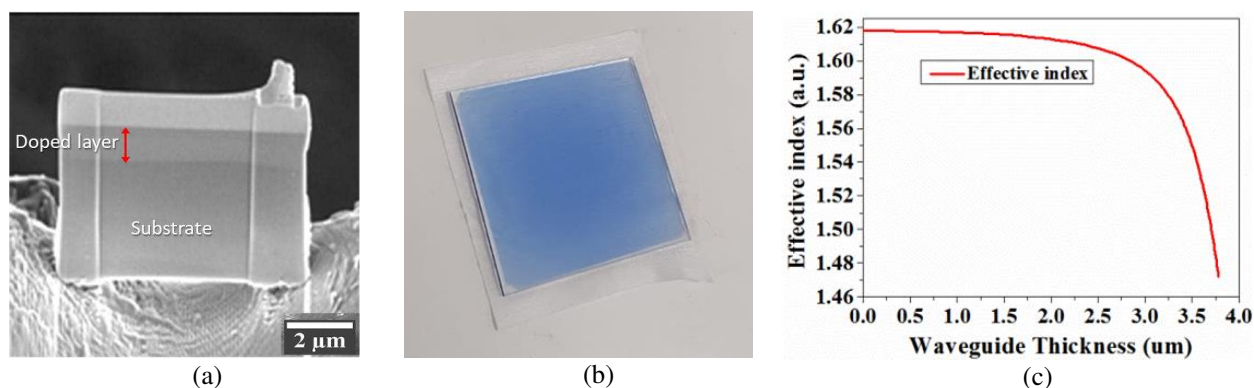


Figure 1

References

- [1] G. Jose, T. Fernandez, P. Steenson, and A. Jha, "Multi-ion diffusion in silica glass using femtosecond pulsed laser deposition," in Conference on Lasers and Electro-Optics 2012, OSA Technical Digest (online) (Optica Publishing Group, 2012), paper CM3L.6.
- [2] J. Chandrappan, M. Murray, T. Kakkar, et al. "Target dependent femtosecond laser plasma implantation dynamics in enabling silica for high density erbium doping," *Sci Rep* **5**, 14037 (2015).
- [3] S. Ahmad Kamil, J. Chandrappan, M. Murray, P. Steenson, T. F. Krauss, and G. Jose, "Ultrafast laser plasma doping of Er^{3+} ions in silica-on-silicon for optical waveguiding applications," *Opt. Lett.* **41**, 4684-4687 (2016).
- [4] P. Pal, Eric Kumi-Barimah, B. Dawson, G. Jose, "Manufacturing of Er^{3+} -doped planar waveguides on silica-on-silicon using femtosecond laser-induced plasma," *Optics Comm.*, **522**, 128614 (2022).
- [5] J. Chandrappan, M. Murray, P. Petrik, E. Agocs, Z. Zolnai, A. Tempez, S. Legendre, D. P. Steenson, A. Jha, and G. Jose, "Doping silica beyond limits with laser plasma for active photonic materials," *Opt. Mater. Express* **5**, 2849-2861 (2015).