

Focusing light through a free-form scattering medium

Rates, Alfredo; Adam, Aurele J.L.; IJzerman, Wilbert L.; Lagendijk, Ad; Vos, Willem L.

DOI

[10.1109/CLEO/Europe-EQEC52157.2021.9542117](https://doi.org/10.1109/CLEO/Europe-EQEC52157.2021.9542117)

Publication date

2021

Document Version

Final published version

Published in

2021 Conference on Lasers and Electro-Optics Europe and European Quantum Electronics Conference, CLEO/Europe-EQEC 2021

Citation (APA)

Rates, A., Adam, A. J. L., IJzerman, W. L., Lagendijk, A., & Vos, W. L. (2021). Focusing light through a free-form scattering medium. In *2021 Conference on Lasers and Electro-Optics Europe and European Quantum Electronics Conference, CLEO/Europe-EQEC 2021* (pp. 1). (2021 Conference on Lasers and Electro-Optics Europe and European Quantum Electronics Conference, CLEO/Europe-EQEC 2021). IEEE.
<https://doi.org/10.1109/CLEO/Europe-EQEC52157.2021.9542117>

Important note

To cite this publication, please use the final published version (if applicable).
Please check the document version above.

Copyright

Other than for strictly personal use, it is not permitted to download, forward or distribute the text or part of it, without the consent of the author(s) and/or copyright holder(s), unless the work is under an open content license such as Creative Commons.

Takedown policy

Please contact us and provide details if you believe this document breaches copyrights.
We will remove access to the work immediately and investigate your claim.

Green Open Access added to TU Delft Institutional Repository

'You share, we take care!' - Taverne project

<https://www.openaccess.nl/en/you-share-we-take-care>

Otherwise as indicated in the copyright section: the publisher is the copyright holder of this work and the author uses the Dutch legislation to make this work public.

Focusing light through a free-form scattering medium

Alfredo Rates¹, Aurèle J. L. Adam², Wilber L. IJzerman^{3,4}, Ad Lagendijk¹, Willem L. Vos¹

1. Complex Photonic Systems (COPS), MESA+ Institute for Nanotechnology, University of Twente,
P.O. Box 217, 7500AE Enschede, The Netherlands

2. Optics Research Group, Department of Imaging Physics, Delft University of Technology,
Lorentzweg 1, 2628 CJ Delft, The Netherlands

3. CASA, Department of Mathematics and Computer Science, Eindhoven University of Technology,
PO Box 513, 5600MB Eindhoven, The Netherlands

4. Signify Research, High Tech Campus 7, 5656AE Eindhoven, The Netherlands

Imaging and transport light through scattering opaque media is a hot topic pursued in multiple fields, ranging from nanotechnology to life sciences. A promising technique to do this is wavefront shaping (WFS), where the light propagation through a scattering medium is controlled by interference [1][2]. Recently, the potential of WFS was even extended to, for instance, time-varying samples [3][4]. In most cases to date, WFS has been done on the quintessential scattering sample geometry, namely in slabs.

Real-world applications, however, require samples to have any shape – “free-form scattering optics” – that defies current theories. Here, we present the study of an opaque sample of TiO₂ particles suspended in silicone. Exploiting the flexibility of silicone, we are able to modify the geometry of the sample and measure the enhancement of the intensity η in a point of the speckle pattern. Using this opportunity, we compare the performance of a flat and a free form sample. These experimental measurements will be compared with a newly formulated theory of light transport in free form scattering media.

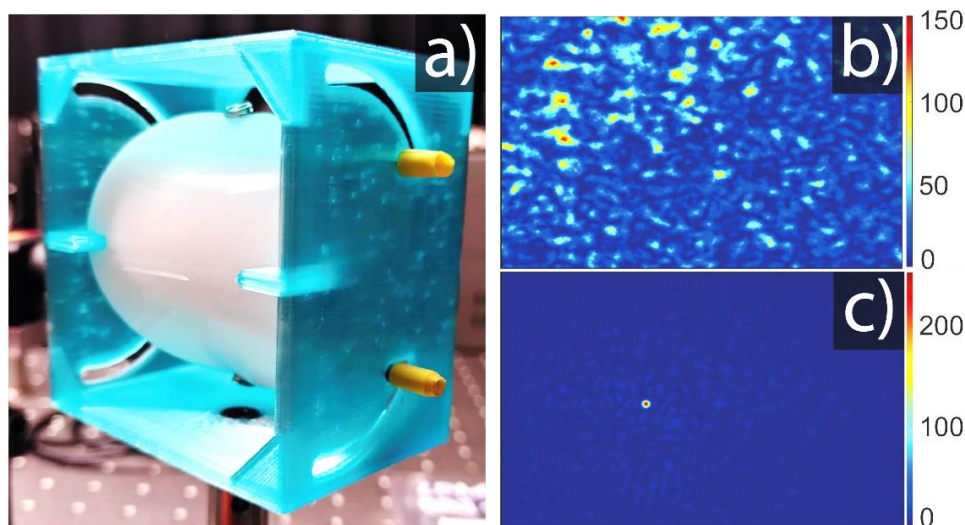


Fig. 1 a) Photo of a free formed (curve) slab, sample of TiO₂ nanoparticles in silicone. b) Speckle when illuminating the bent sample with plane waves. c) Wavefront shaping leads to a brighter spot even when transmitted through a free-formed scattering sample.

References

- [1] I. M. Vellekoop and A. P. Mosk, "Focusing coherent light through opaque strongly scattering media," *Opt. Lett.* **32**, 2309-2311 (2007)
- [2] A. Mosk, A. Lagendijk, G. Lerosey and M. Fink, "Controlling waves in space and time for imaging and focusing in complex media," *Nature Photon* **6**, 283–292 (2012).
- [3] J. Brake, M. Jang, and C. Yang, "Analyzing the relationship between decorrelation time and tissue thickness in acute rat brain slices using multispeckle diffusing wave spectroscopy," *J. Opt. Soc. Am. A* **33**, 270-275 (2016)
- [4] D. Feldkhun, O. Tzang, K. H. Wagner, and R. Piestun, "Focusing and scanning through scattering media in microseconds," *Optica* **6**, 72–75 (2019)