Micro-scale lensless imaging and laser printing in 3D

(MSc. Project)

Utrecht University, June 2021

Main research question

Using high-intensity laser beams, can we manufacture microscale 3D sculptures in glass/plastic and recover their structure using lensless imaging?

Description

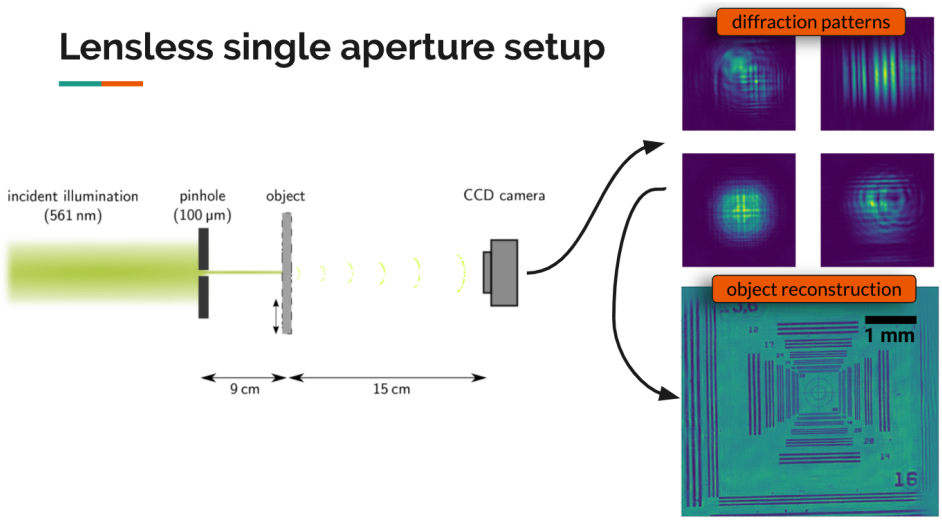

Figure 1: The concept of ptychography. Coherent diffraction patterns downstream of an illuminated object are detected with a camera while the object is laterally scanned. The data are used to algorithmically reconstruct the object and illuminating field.

Ptychography is a lensless method that allows for wavefront sensing and phase-sensitive microscopy using coherent illumination of an object [1]. We are using a Deep Learning based approach [2] to reconstruct 2D images from diffraction patterns as shown in Figure 1. The student project will play a key role in elevating this method to 3D. To that end, we want to obtain a sub-surface 3D structure in the micro-scale. This can be achieved by so-called vitrography to produce a *bubblegram* (see Figure 2): a laser is focused to high intensity inside the medium which is mounted on an opto-mechanical system. Even though the medium is transparant, multi-photon absorption at very high intensities will induce a visible change in the refractive index at the focal spot. While working on this project, you will both develop such a 3D laser engraving system (including software and optical setup), and acquire a deep understanding of the principles of 3D lensless imaging.

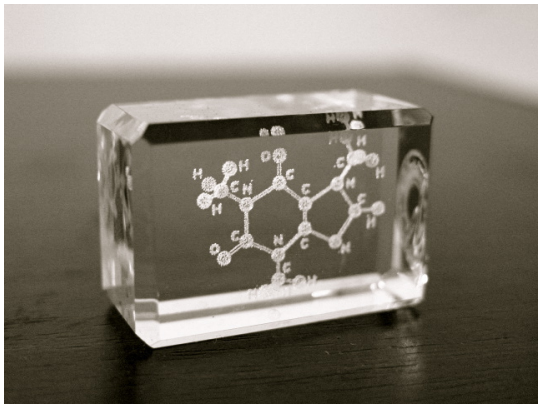

Figure 2: A laser glass sculpture of a caffeine molecule. [en.wikipedia.org/wiki/Bubblegram]

About the research group

You will join the Nanophotonics group, which investigates and explores non-conventional methods of imaging in scattering materials by integrating concepts from distinct fields such as space-time wavefront shaping, optical metrology, lensless imaging, and laser ablation. We are a mid-sized group of researchers and staff with diverse backgrounds and specifically encourage applicants of underrepresented groups to apply.

Requirements

- good theoretical knowledge of electrodynamics, photonics and/or optics
- motivation to work in a laser lab
- some programming experience (e.g., Python) could be helpful

Contact

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References

[1] John Rodenburg and Andrew Maiden. Ptychography. In Peter W Hawkes and John C H Spence, editors, *Springer Handbook of Microscopy*, page 2. Springer International Publishing, Cham, 2019.

[2] Jacob Seifert, Dorian Bouchet, Lars Loetgering, and Allard P Mosk. Efficient and flexible approach to ptychography using an optimization framework based on automatic differentiation. *OSA Continuum, OSAC*, 4(1):121–128, January 2021.