Interferometric Profilometer

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

EMSI – Engineering Mechanics of Soft Interfaces

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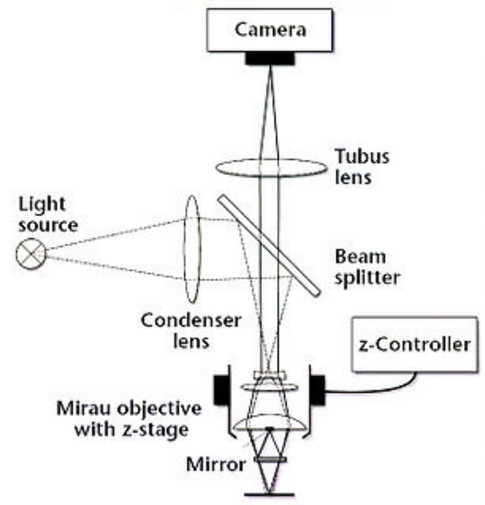
Our aim

Our task was to build a white light optical profilometer for laboratory use. Many professional profilometers of this type already exist but are, however, very costly. Having understood the basic working principles of these devices, it seemed interesting and challenging to construct our own model.

We started off with the construction of an interferometer, before moving on to programming a software that would process the images and eventually reconstruct the nanometric surface profile.

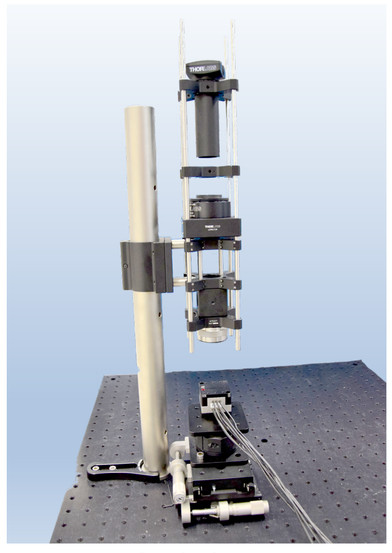


Operating principle of our profilometer

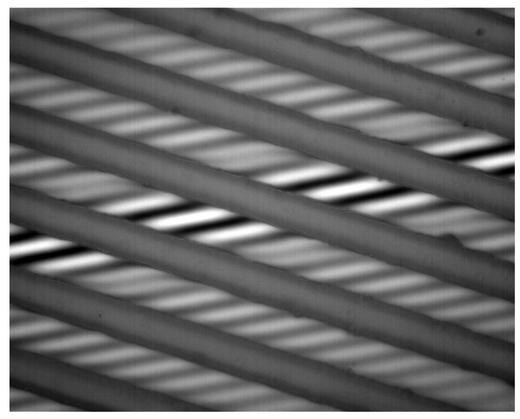
Our achievements

Using a piezo-controller, a nanometric precision z-stage, a camera and optical instruments such as lenses and mirror, we constructed a pretty compact and simple design.

The z-scanning is automated and synchronised with the camera in order to capture an image every 100 [nm] or less. Our code, using an algorithm detecting the maximum intensity of interference of each pixel, then generates a 2D coloured image of the surface profile!



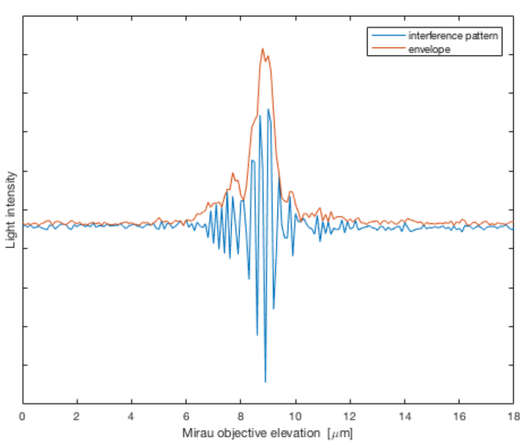
Our final setup



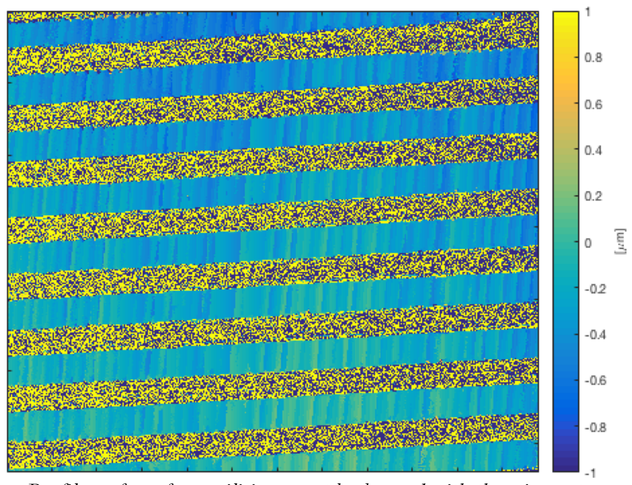
Interference fringes on a silicium sample surface observed on our setup

Results

- We first used the z-scanning interferometry technique with an already built high-precision microscope and processed the data we got on MATLAB.

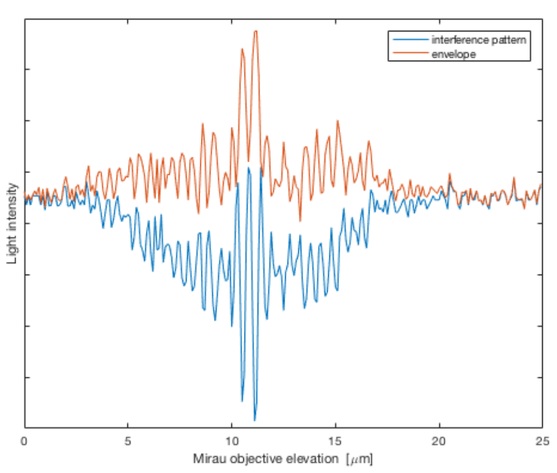


Z-scanning interference pattern observed with the microscope

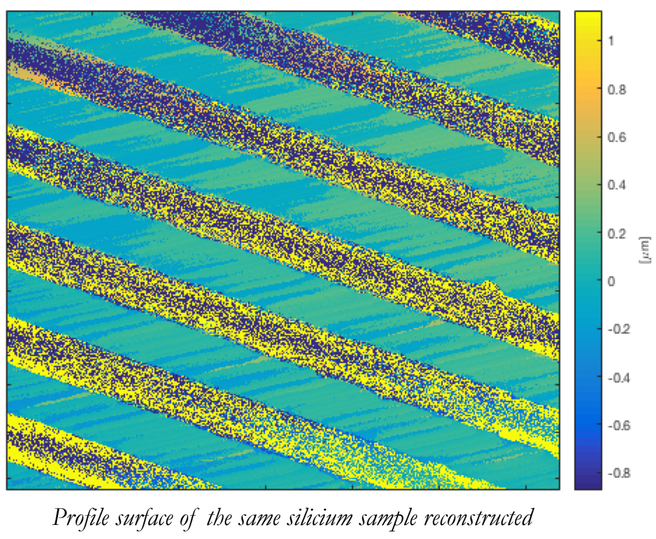


Profile surface of our silicium sample observed with the microscope

- We then followed the same steps on the setup we built.



Interference pattern observed with our setup



Profile surface of the same silicium sample reconstructed with our setup !

The differences between the results come down mainly to the fact that our setup is exposed to a considerable amount of vibration whereas the microscope is nicely isolated. This explains the noise observed on our setup. An important point of improvement would be to find a way to minimize the impact of these vibrations on our results.

Conclusion

This project was a great way to learn and get introduced the way research in laboratory works. Indeed, right from the start we encountered numerous issues and had to learn to break the problems down to resolve them individually. Each problem seemed to contain another load of complications we had to solve, and we were quickly immersed in the reality of researching. Eventually, after many weeks of experimenting with various setups and trying countless methods of aligning the components, observing interference was a joy!

Major difficulties encountered

- Understanding the functioning and limitations of the optical instruments and light sources,
- The high precision needed for the positioning of each component of the profilometer, and finding the methods necessary to position each part correctly,
- Finding a way to reduce the amount of noise when recording the images, resulting in a loss of precision in the reconstruction,
- Understanding how to control the software needed for each step of the process individually.

What's next?

Now that the profilometer is up and working, it would be great to get the opportunity to develop a user interface controlling all the different variables and software needed to obtain the 3-dimensionnal image of an entire surface. This requires communication and synchronization between the profilometer stage, the camera software, the image processing software and computing software (MATLAB) to analyse the pictures taken. This would allow us to automatize completely the whole process.

Image source : https://wikivisually.com/wiki/Profilometer