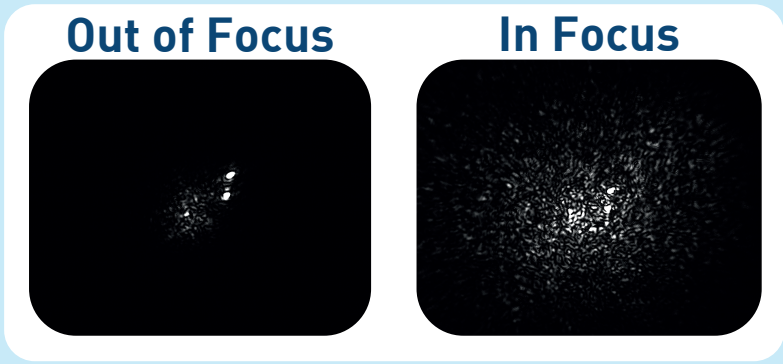
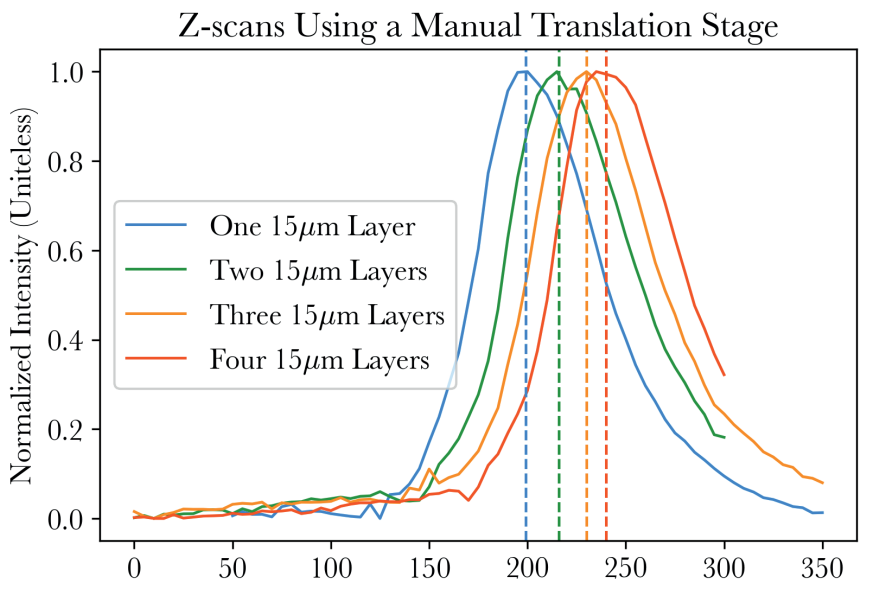
Data Analysis

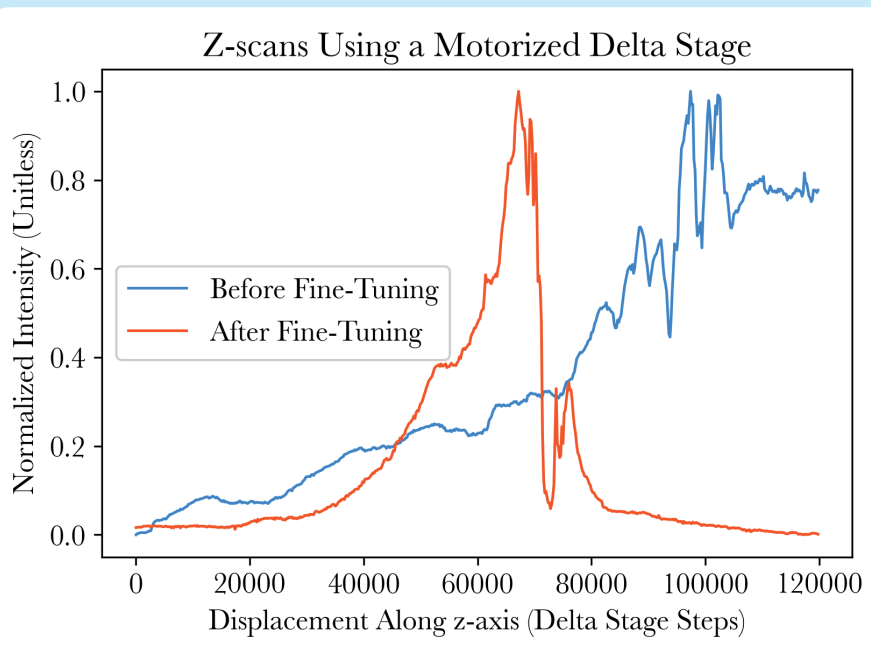
The data in form of many images is analysed in Python using the OpenCV library. The images are converted into grayscale while accounting for the relative luminosity of the RGB colors. The grayscale image arrays are then averaged to obtain a single value which represents the average intensity over the whole image sensor. These intensities are then normalized and plotted against the z displacement giving a curve for the z-scan. This is then repeated for multiple z-scans and the difference in the z-coordinates of the peaks is used to determine the height of the structures being scanned.





Results

To test the optical setup, a single layer of electrical tape has been used as a sample and a z-scan was performed using a manual translation stage and increments of 5 µm. This process was then repeated each time adding a layer of electrical tape. The shift of the peaks was then used to calculate the average thickenss of 1 layer of electrical tape to be 13.7 µm (3sf). Using a micrometer the thickness was measured to be 15 ± 1 µm (2sf). One of the issues with using electrical-tape is that it is elastic and therefore its thickness is not constant. Overall this result shows that even with 5 µm increments the setup is capable of micrometer precision.



Improvements

The repeatability of the stage has been improved by lubricating the driving mechanism of the stage and overdriving the steppers using a higher voltage. The calibration of the DS has been solved by mounting it onto a linear translation stage with a micrometer gauge which can be used as a reference. In future experiments, the delta stage should be replaced by a block stage [3] better suited for this setup. The camera should be replaced by either a laboratory camera such as the one made by ThorLabs, or a photodiode as described previously.

Complications

Even in its current state, the project involves multiple complications limiting its functionality as shown on the z-scans using the motorised stage. Initially the DS has shown poor repeatability due to the steppers losing steps. Since the OpenFlexure software defines displacement in terms of steps, and the range of the DS is limited due to the driving screws being unscrewed, it was difficult to choose a reasonable range for the z-scans. Currently the most significant issue of the setup is caused by unwanted image processing in the OpenFlexure software and the relatively low dynamic range of the camera. This is indicated by the smooth curve edges and a broken up peak.

References

[1] Breaking Taps, “I made a scanning laser microscope”, 21.6 2021, Available: https://youtu.be/9TYlQ4urcg8

[2] S. McDermott et al., “Multi-model microscopy imaging with the OpenFlexure Delta Stage,” arXiv preprint arXiv:2112.05804, 2021.

[3] Q. Meng, K. Harrington, J. Stirling, and R. Bowman, “The OpenFlexure Block Stage: sub-100 nm fibre alignment with a monolithic plastic flexure stage,” Optics Express, vol. 28, no. 4, pp. 4763–4772, 2020.