Optics EXPRESS

Fourier ptychographic topography: supplement

HAO WANG,¹ JIABEI ZHU,¹ D JANGWOON SUNG,² GUORONG HU,¹ JOSEPH GREENE,¹ D YUNZHE LI,¹ D SEUNGBEOM PARK,² WOOKRAE KIM,² MYUNGJUN LEE,² D YUSIN YANG,³ AND LEI TIAN^{1,4,*} D

¹Department of Electrical and Computer Engineering, Boston University, MA 02215, USA ²MI Equipment R&D Team, Mechatronics Research, Samsung Electronics Co., Ltd., Hwasung 18848, Republic of Korea

³Process Development, Semiconductor R&D Center, Samsung Electronics Co., Ltd., Hwasung 18848, Republic of Korea

*leitian@bu.edu

This supplement published with Optica Publishing Group on 17 March 2023 by The Authors under the terms of the Creative Commons Attribution 4.0 License in the format provided by the authors and unedited. Further distribution of this work must maintain attribution to the author(s) and the published article's title, journal citation, and DOI.

Supplement DOI: https://doi.org/10.6084/m9.figshare.22218238

Parent Article DOI: https://doi.org/10.1364/OE.481712

⁴Department of Biomedical Engineering, Boston University, MA 02215, USA

FOURIER PTYCHOGRAPHIC TOPOGRAPHY: SUPPLEMENTAL DOCUMENT

This document provides supplementary information to "Fourier ptychographic topography". Here, we show more details about the resolving power of our FPM system and provide the high-resolution optical profilometer measurement of different patterned samples.

1. ANALYSIS OF THE RESOLVING POWER OF FPT

Here, we estimate the Contrast Transfer Function (CTF) of the FPT by analyzing the reconstruction results on the resolution target.



Fig. S1. Contrast transfer function. (a) The amplitude reconstruction with all BF LEDs. (b) The amplitude reconstruction with all the BF and DF LEDs. (c) The CTF of reconstruction with only BF LEDs (blue line), and all BF and DF LEDs (red line).

As shown in Fig. S1, the contrast, calculated by C = (Imax - Imin)/(Imax + Imin), is estimated for different elements in the reconstructed images. Because there is dust on our resolution target, we try to find the clean position to calculate the contrast for different elements, as noted by the dashed red lines in Fig. S1 (a) and (b).

For the reconstruction only with all BF LEDs, the diffraction-limited resolution is 630/0.56 = 1125nm, corresponding to the spatial frequency 888.9mm⁻¹. The spatial frequency of Group

9, Element 5 is 812.7mm⁻¹, and of Group 9, Element 6 is 912.2mm⁻¹. As shown in Fig. S1(a) and (c), we can distinguish Group 9, Element 5 and the contrast is 0.15. For Group 9, Element 6, as shown in the zoomed-in red box in Fig. S1(a), we can roughly distinguish lines and space, but it is harder to tell details compared with Group 9, Element 5. The contrast decreased to 0.05 for Group 9, Element 6.

For the reconstruction using all the BF and DF LEDs, the diffraction-limited resolution is 630/0.84 = 750nm, corresponding to the spatial frequency 1333.3mm⁻¹. The spatial frequency of Group 10, Element 3 is 1290.1mm⁻¹, and of Group 10, Element 4 is 1448.2mm⁻¹. As shown in Fig. S1(b) and (c), we can distinguish Group 10, Element 3 and the contrast is 0.2. For Group 10, Element 4, it is harder to tell the details of the vertical lines/space as shown in the zoomed-in red box in Fig. S1(b). The contrast decreased to 0.11. The reason why we can achieve a slightly better resolution than the diffraction-limited resolution may be the use of the TV regularization, which provides prior information on the sample.

Overall, our reconstruction can achieve the diffraction-limited resolution.

2. ROBUST MEASUREMENT OF FPT

We use our FPT to measure different patterned samples and use Zygo optical profilometer to measure the same samples. The results are shown below. The Zygo fails to correctly measure these samples with fine structures. However, our FPT method can correctly reconstruct the height maps of all these patterns.



Fig. S2. The left two columns are the Zygo measurements and the corresponding height profiles. The right two columns are the FPT reconstruction and the corresponding height profile. Zygo fails to correctly measure the sample surface profile, while our FPT method can robustly perform the reconstruction on these samples.