Photolithographic Patterning of Alignment Fiducials for X-Ray Nano-Diffraction

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Primary CNF Tools Used: Heidelberg Mask Writer - DWL2000, Hamatech Mask Chrome Etch, ABM Contact Aligner

Abstract:

Alkaline fuel cells and electrolyzer cells are promising alternative forms of energy conversion and storage devices due to their potential for eliminating the need for precious-metal catalysts. Epitaxially grown transition metal oxide thin films have demonstrated promising activity for the oxygen reduction reaction [1], the rate-limiting step for catalysis in alkaline fuel cells. To better understand localized structural and electronic changes in the catalyst under operating conditions, we aim to study them using x-ray nano-diffraction and x-ray absorption near-edge structure at the hard x-ray nanoprobe beamline at the National Synchrotron Light Source II.

Summary of Research:

Focusing of x-rays to a 25 nm spot on a sample requires alignment fiducial markers with sharp edges of less than half a micron in width. Using the computer-aided design software L-Edit and the Heidelberg Mask Writer - DWL2000, we designed and wrote a 5-inch photomask with multiple configurations of the pattern shown in Figure 1. Using S1800 series positive tone photoresist and the ABM Contact Aligner, we transferred the pattern onto samples of sizes 5 mm × 5 mm and 10 mm × 10 mm. DC magnetron sputtering (Cornell Center for Materials Research) was used to deposit 10 nm of titanium and 50 nm of copper metal onto the samples. Sonication in acetone was used to lift off the excess metal and complete the process.

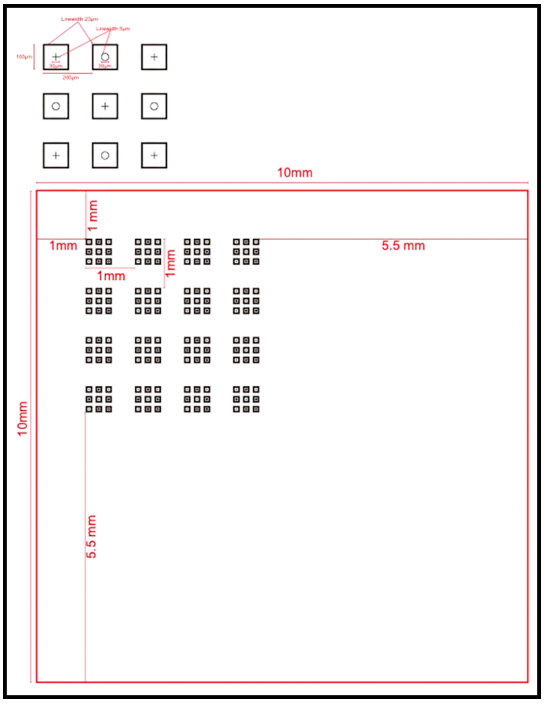

Figure 1: Schematic credit to Dr. Ludi Miao. Arrays of circles and crosses contained in larger squares.

Conclusions and Future Steps:

The fabrication of alignment features was completed successfully and tested at the hard x-ray nanoprobe beamline. For future measurements, we will design and make proof-of-concept devices at the Cornell NanoScale Facility (CNF) for a three-electrode electrochemical cell compatible with the limitations of the beamline. Prior work that used CNF tools was published and presented as detailed below.

Publication:
https://doi.org/10.1063/5.0125268

Conference presentation, 2022 Materials Research Society (MRS) Fall Meeting: Title: "X-ray Nano-Imaging of Defects in Thin-Film Catalysts via Cluster Analysis."

References:

[1] Y. Yang, et al. J. Am. Chem. Soc. 2019, 141, 1463-1466.