TEM Report 3

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1 Introduction

This report will focus on the the analysis of the diffraction patterns that were acquired in the Center for Electron Microscopy and Nanofabrication (CEMN) at Portland State University (PSU) on May 23rd, 2014. Diffraction patterns, a Kikuchi pattern and a High Resolution Transmission Electron Microscope (TEM) (HRTEM) images were acquired using an FEI Technai TEM.

This paper will cover a brief conceptual/theoretical description of diffraction pattern formation. We will then analyze diffraction patterns of a Aluminum (Al) polycrystalline sample and a single-crystalline Silicon (Si) sample. We will also analyze the lattice structure and spacing of a gold foil sample using a HRTEM image taken of the sample. A Kikuchi pattern is also included and briefly discussed.

2 Diffraction Pattern Formation

Diffraction patterns in a TEM are formed when incoming parallel beams of electrons interact with the crystal lattice structure of a sample. They deflect off the different planes of the structure according to brags law. The electrons that bounce of the same plane are reflected into parallel beams. When these parallel rays are focused through the objective lens, all the different sets of electrons traveling in parallel paths are focused into distinct bright points forming a diffraction pattern. An example of this can be seen in Figure 1 which shows a simplified version of this process. In actuality, you would want to form the image of the diffraction pattern on the actual screen or camera you are taking data with.

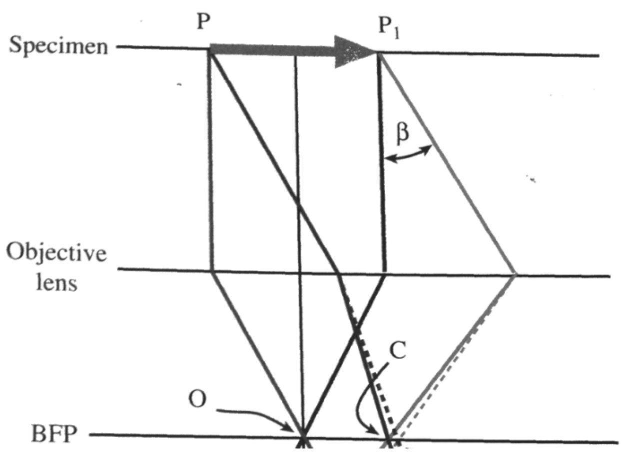
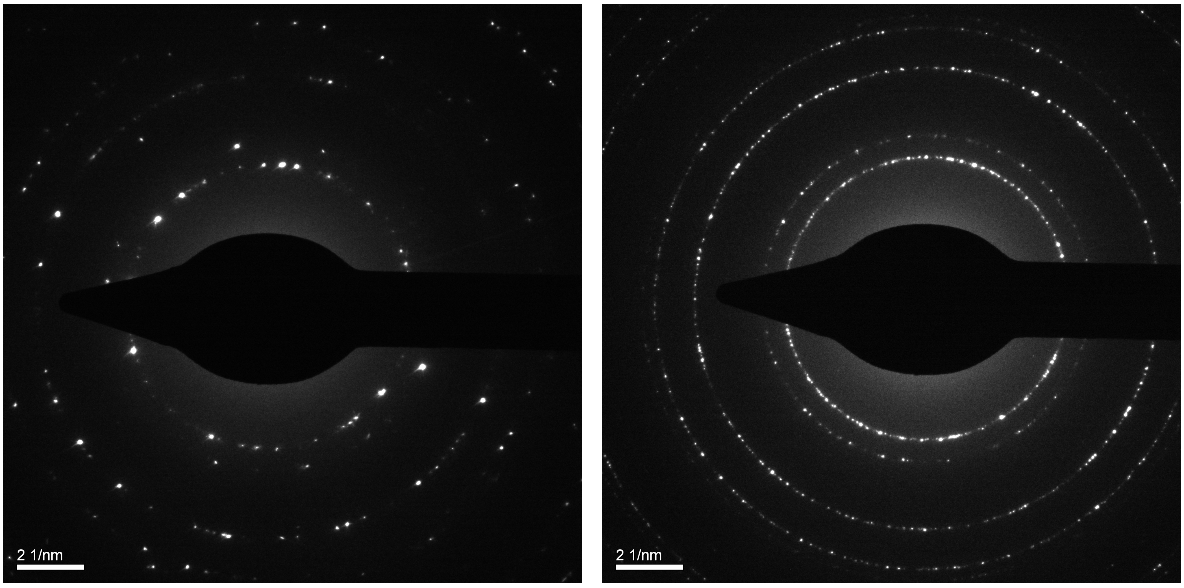


Figure 1: Outgoing parallel rays focused into discrete points to form a diffraction pattern.[2]

We can use the addition of a Select Area Electron Diffraction (SAED) aperture to further enhance our diffraction pattern. The SAED aperture resides in image plane, allowing us to block out parts of our sample by literally blacking out the parts we are not interested. Once this aperture is set in imaging mode, switching back to the diffraction pattern mode, the resulting pattern will be generated only by the parts of our sample we included in our image from the imaging plane. This is useful when our sample is made up of a number of discrete samples and we are only interested in the diffraction pattern of a particular piece of the sample at one point.

2.1 Aluminum Polycrystalline Diffraction Pattern

The fist diffraction pattern we will be analyzing is from an Aluminum Polycrystalline Diffraction Pattern. Polycrystalline samples, being made up of many crystallites, generate distinct circular diffraction pattern. Two different images of different diffraction patterns generated from our Aluminum sample are shown in Figure 2.



(a) aluminum polycrystalline pattern using SAED setting 2

(b) aluminum polycrystalline pattern using SAED setting 3,

Figure 2: Aluminum Polycrystalline Diffraction Patterns

The two different patterns are generated by changing the the SAED setting on the TEM. By selecting different locations on the sample using this aperture described in 2, we are able to see the different diffraction patterns from different structures on our sample.

By using a higher SAED setting, we can also decrees the brightness of the the bright spots seen in Figure 2a. This can enhance the contrast of the dimmer points and allow us to take an image that contains more discernible detail. Figure 2b appears brighter, but this is actually a result of imaging a darker, more contrast rich image with the reduction of the distict bright points seen in Figure 2a.

2.1.1 D Spacing

2.2 Single-Crystalline Silicon Diffraction Pattern

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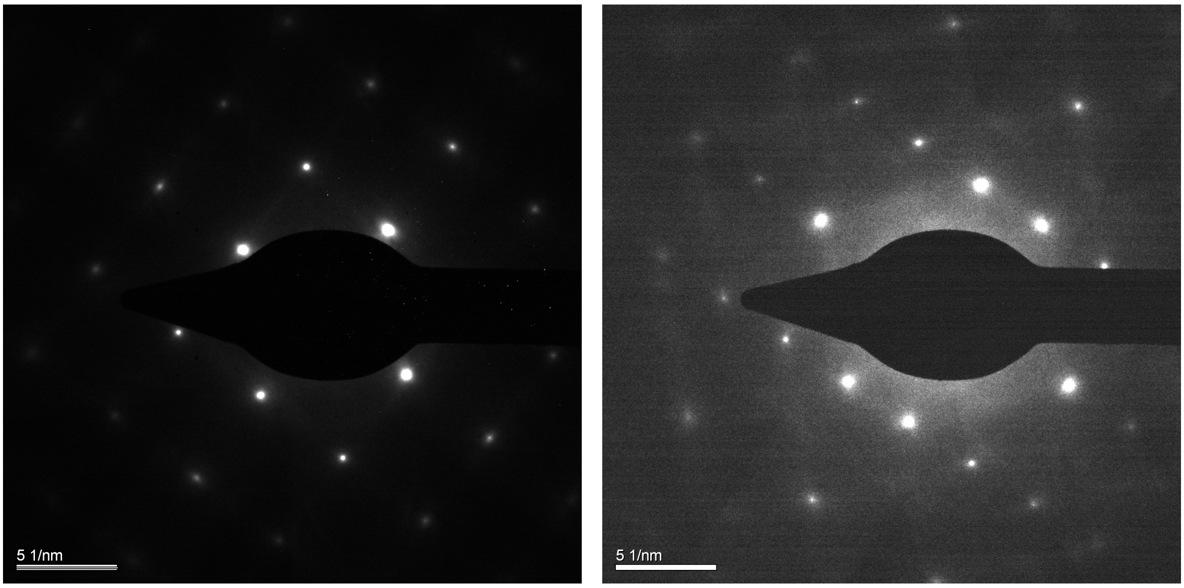

(a) single-crystalline silicon pattern at one zone axis

(b) single-crystalline silicon pattern at another zone axis

Figure 3: Single-Crystalline Silicon Diffraction Pattern

2.3 Silicon Kikuchi Pattern

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3 Lattice Structure Fundamentals

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3.1 Lattice Spacing of Gold Foil Sample

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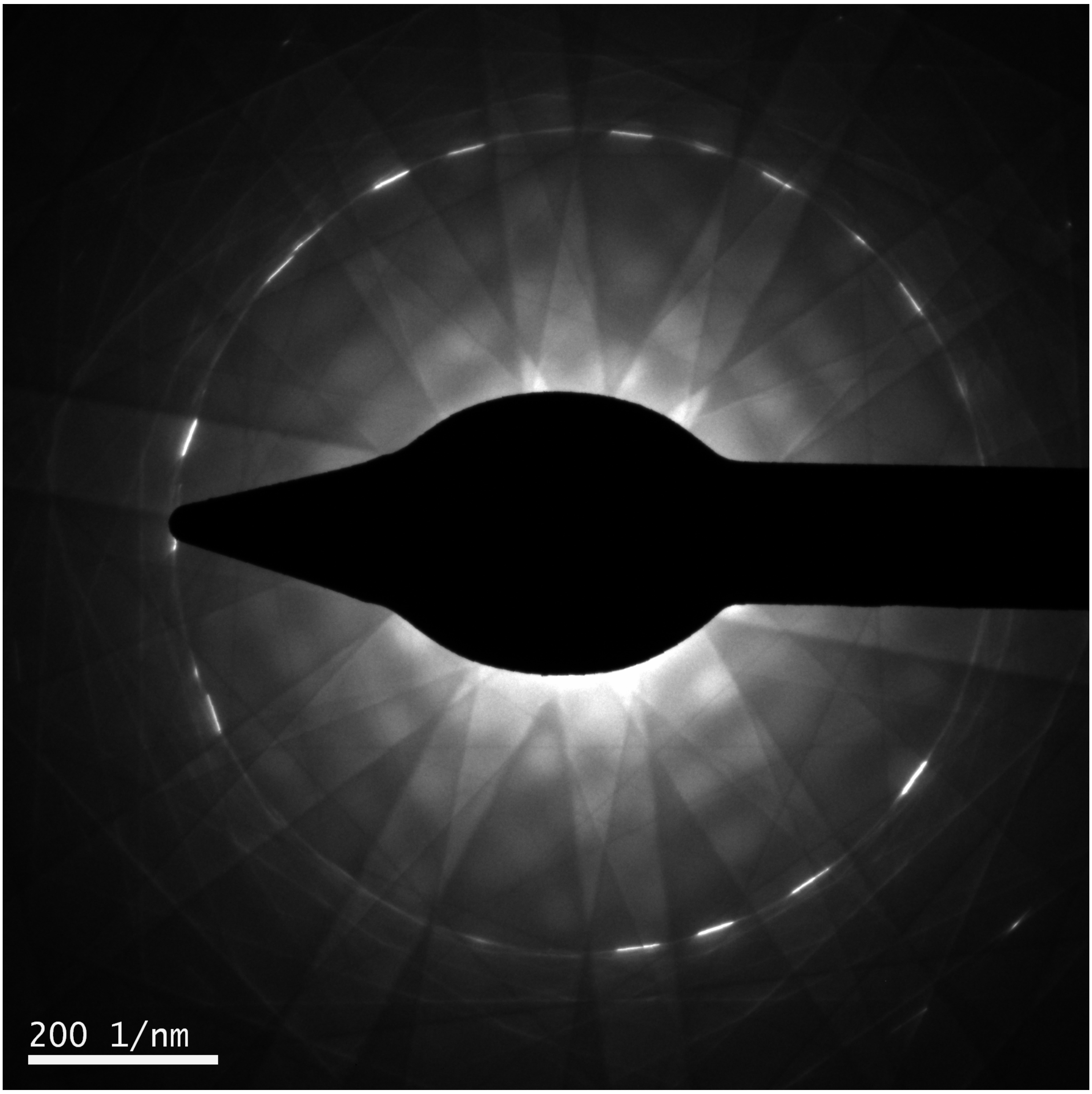

Figure 4: Silicon Kikuchi pattern

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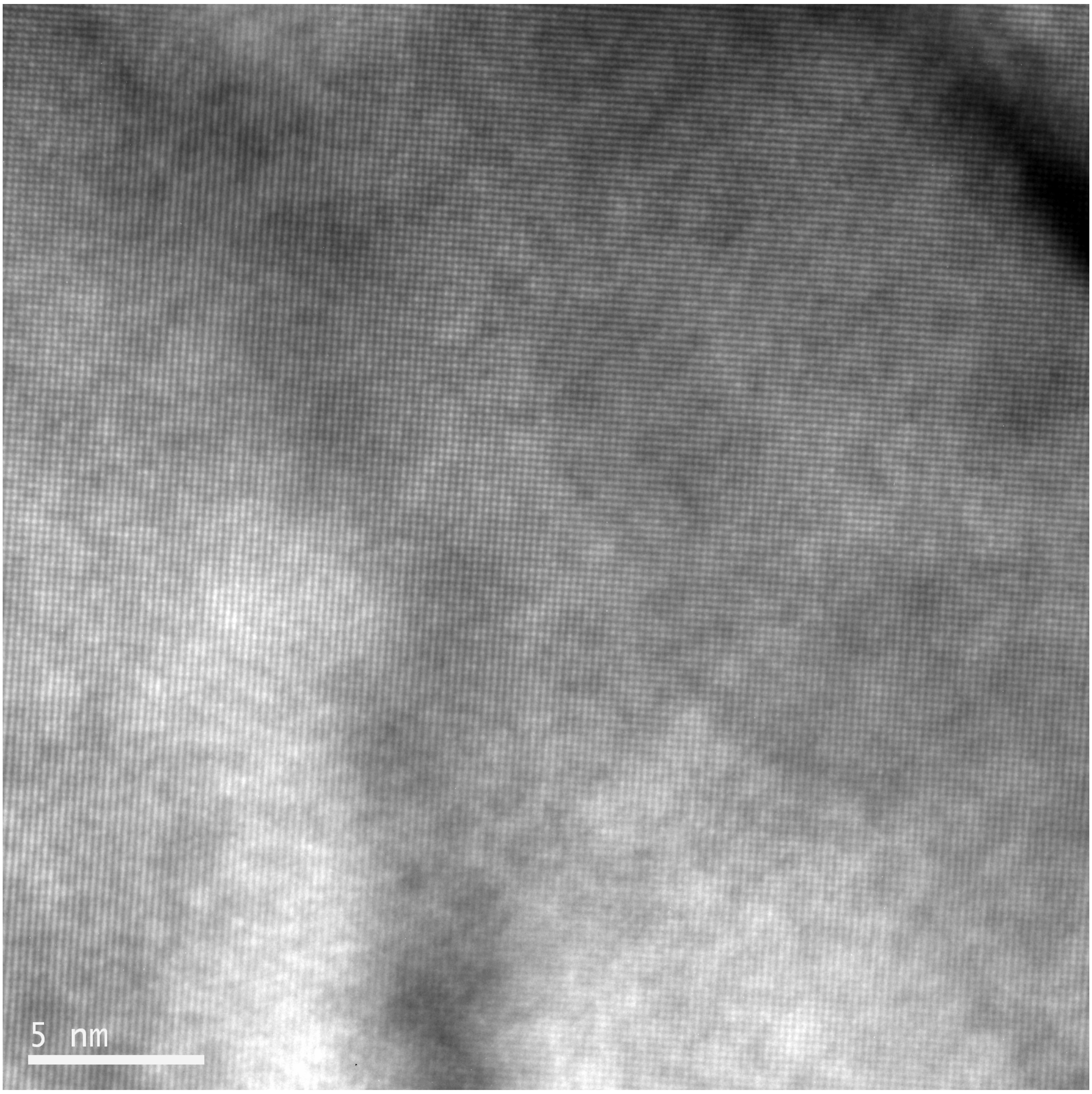

Figure 5: Al HRTEM image

4 Conclusion

References

[1] homebrew-science. https://github.com/Homebrew/homebrew-science, 2014.

[2] C. Carter D. Williams. *Transmission Electron Microscopy*. Springer, 2009.

[3] J. M. Wojdyr. fityk.nieto.pl. *Appl. Cryst.*, 43(1126), 2010.