Development of a Side-View System for Atomic Force Microscopy (AFM)

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This study presents the development of a side-view imaging system for atomic force microscopy (AFM). The system consists of a monochromatic camera, two lenses, a light source, and image processing software. Six qualitative tests were conducted to evaluate the system's field of view and resolution. The field of view tests used a target positioned both horizontally and vertically. In contrast, the high-resolution test was conducted with the target fixed horizontally and an exposure time of 3,000 milliseconds in both tests. The results allowed the evaluation of the optical system's performance. They demonstrated its feasibility for side imaging in the AFM system under development at the Optics Laboratory, ensuring greater precision in the probe's approach to the sample.

Keywords: Atomic Force Microscopy. Imaging System. Characterization.

Atomic force microscopy (AFM) encompasses a wide range of applications, from the study of polymer surface morphology to the examination of morphological, structural, and molecular properties at the nanoscale [1]. The AFM operates based on the interaction between an excellent tip and the sample under investigation. By detecting these interactions, the equipment can map surface topography and properties at nanometric resolution. A visualization system is essential for observing the probe and sample. Thus, a dedicated imaging system is required, specifically a side-view system for the AFM under development in the Optics Laboratory. This system comprises an imaging sensor (color or monochromatic), one or more lenses for image conditioning, a light source, and image processing software. The choice of materials for the side-view system was based on the AFM system being developed in the NA@MO Project. A Basler camera was selected due to its similar technical specifications (sensor and pixel size) to the camera used in NA@MO, differing only in that it is monochromatic instead of color. Accordingly, this test aims to characterize and validate the best configuration and component selection for the AFM side-view system under development in the Optics Laboratory.

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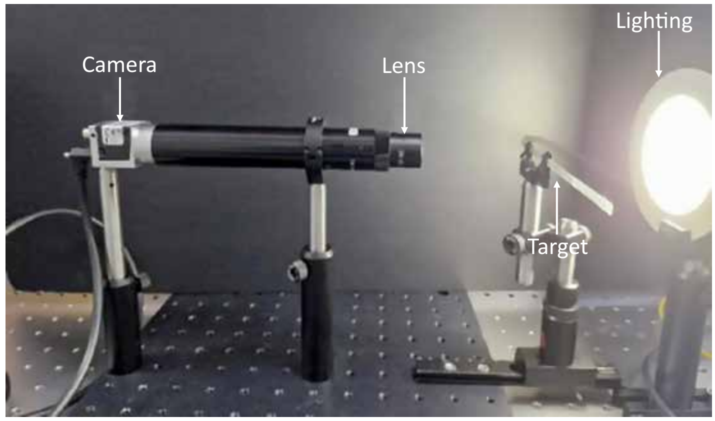
Materials and Methods

The characterization of the side-view system was performed through six experimental tests—four for field of view evaluation and two for resolution analysis, all of which were qualitative in nature. The experimental setup consisted of a Basler acA2440-35um monochromatic camera, a lens, and an illumination system (Figure 1). Additionally, an analysis was conducted regarding the distances between the sensor and the lens, and between the lens and the object. For the field of view analysis, two different lenses were tested: a 3x Mitutoyo Compact Objective coupled with a 152.5 mm extension tube, and a 3x 65 mm CompactTL Telecentric Lens. A CB760-80010 print tape was used as the target, positioned both vertically and horizontally. For resolution evaluation, both lenses were used, with the HIGHRES-1 target from Newport placed horizontally.

In all configurations, targets were exposed for 3000 ms to ensure uniformity in image acquisition.

Descriptions of each test are detailed below:

Figure 1. Experimental setup illustration.



Experiment 1: Field of view test – Basler acA2440-35um camera, 3x Mitutoyo Compact Objective, CB760-80010 target horizontally.

Experiment 2: Field of view test – Basler acA2440-35um camera, 3x Mitutoyo Compact Objective, CB760-80010 target vertically.

Experiment 3: Field of view test – Basler acA2440-35um camera, 3x 65 mm CompactTL Telecentric Lens, CB760-80010 target horizontally.

Experiment 4: Field of view test – Basler acA2440-35um camera, 3x 65 mm CompactTL Telecentric Lens, CB760-80010 target vertically.

Experiment 5: High-resolution test – Basler acA2440-35um camera, 3x 65 mm CompactTL Telecentric Lens, HIGHRES-1 target horizontally.

Experiment 6: High-resolution test – Basler acA2440-35um camera, 3x Mitutoyo Compact Objective, HIGHRES-1 target horizontally.

The tape-type target has 6 line pairs per mm (lp/mm); the horizontal and vertical field of view was calculated by dividing the number of visible line pairs by 6, resulting in the total dimension in millimeters. For resolution, the maximum value was identified by the group where the separation between lines was still distinguishable.

Results and Discussion

Figure 2 shows the results of the experiments.

After testing, it was observed that the 3x Mitutoyo Compact Objective lens achieved a field of view of 2.75 x 2.29 mm, while the 3x 65 mm CompactTL Telecentric Lens achieved 2.71 x 2.27 mm—1.59% smaller than the first lens.

Regarding resolution, the first lens resolved Group 7.3 at 161.3 lp/mm, corresponding to a pixel size of 3.10 µm, while the second lens resolved Group 7.2 at 143.7 lp/mm, representing a 10.92% improvement for the Mitutoyo lens.

As shown in Figures 3 and 4, the total distance from sensor to object was 262.52 mm for the first system and 141.53 mm for the second. Despite the 3x Mitutoyo lens's better optical performance, its larger working distance results in a bulkier setup, making focus adjustments more challenging.

Conclusion

The configuration using 3x65 mm CompactTL Telecentric Lenses was chosen, prioritizing a compact and functional side-view system. Although

Figure 2. Experiment results.

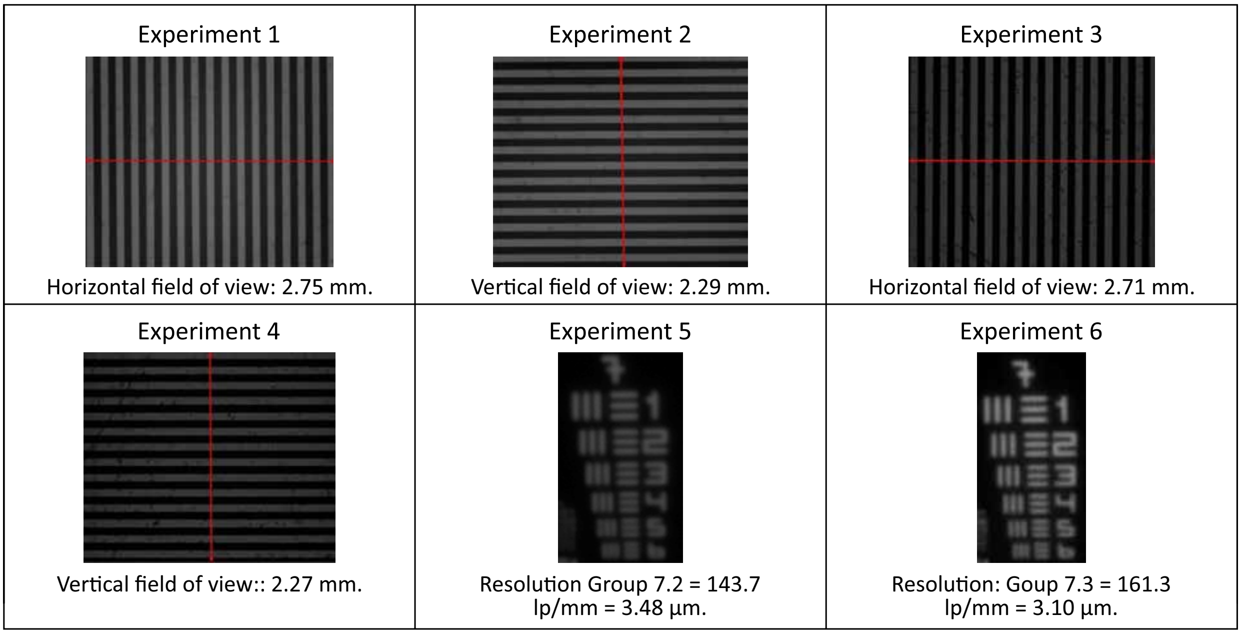


Figure 3. Mitutoyo lens measurements.

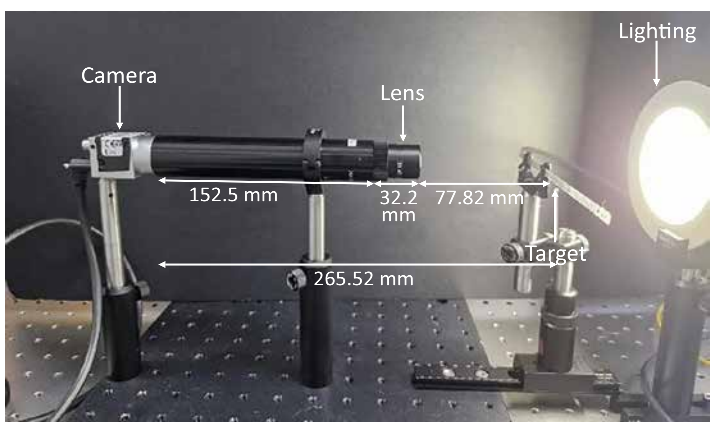
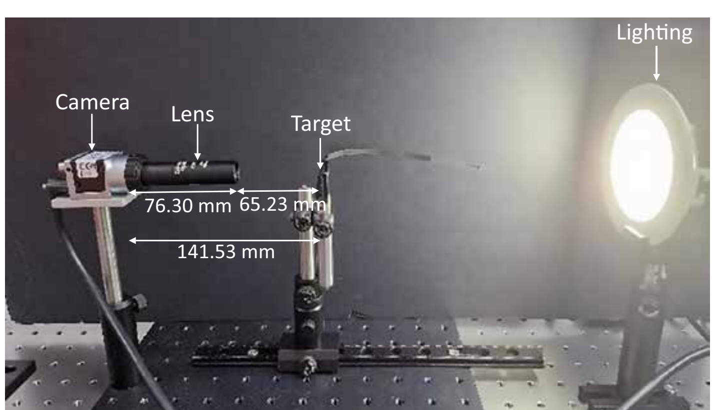


Figure 4. Telecentric lens measurements.



slightly lower in performance, this configuration meets the project requirements and offers a practical advantage in terms of compactness.

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References

1. Herrmann PSP, Silva MAP, Fonseca RB, et al. Microscopia de varredura por força: uma ferramenta poderosa no estudo de polímeros. Polímeros. 1997;7:51–61. Available from: https://doi.org/10.1590/S0104-14281997000400009.