APPLICATION NOTE

Resolution Verification of the LIG-Nanowise SMAL Lens Using the Newport HIGHRES-1 USAF Target

Comparison With SEM Imaging and a 100× Objective Lens

1. Introduction

The LIG Nanowise SMAL (Super-Resolution Microsphere Amplifying Lens) is an optical module designed to achieve lateral resolution significantly beyond the diffraction limit of conventional microscopy. To verify its true resolving power, we evaluate the SMAL lens using the **Newport HIGHRES-1 USAF resolution target**, which contains features down to **137 nm**—dimensions that standard optical objectives cannot resolve.

This application note demonstrates that the SMAL lens successfully resolves the smallest features on the HIGHRES-1 target and compares its performance with both **SEM ground-truth imaging** and a conventional **100× high-NA objective**.

2. The Newport HIGHRES-1 Target

The HIGHRES-1 consists of a **quartz substrate** patterned with a **100 nm chromium layer**, forming a high-precision USAF-1951 resolution chart. Its smallest features—**Group 11, Element 6**, with **137 nm lines and 137 nm spaces (3,649 lp/mm)**—are below the diffraction limit of visible-light microscopy. Newport notes that these structures are typically *only easily resolved using SEM*, making the target suitable for validating super-resolution imaging performance.

3. Experimental Setup

3.1 SMAL Lens Optical Imaging Setup

- LIG Nanowise SMAL™ lens mounted on LIG Nanowise microscope Nanoro M
- High-NA No immersion configuration
- Wideband LED illumination
- Scientific CMOS camera for image capture

The SMAL lens was aligned to maximize near-field coupling, enabling imaging beyond the diffraction limit.

3.2 Control Imaging Using a 100× Objective Lens (UV-Enhanced Reference)

As a control, a high-quality **100× UV-capable objective** (NA ≈ 1.2) was evaluated using methodology reported by JMC Scientific Consulting for the Newport HIGHRES-2 slide. Although a related model, the HIGHRES-2 contains identical USAF feature dimensions to HIGHRES-1.

Under **313 nm UV illumination**, the 100× objective resolved features down to the **~150–200 nm range**, including Groups 10 and parts of Group 11. However, the smallest **137 nm structures (Group 11, Element 6)** were at or below the limit of detection, consistent with the theoretical diffraction limit even under UV illumination.

This confirms the expected performance:

- **100× objective** resolves down to ~150–200 nm
- **Cannot reliably resolve 137 nm**
- Serves as a meaningful high-end optical reference but not a super-resolution method

Source: UV Microscopy – Resolution testing with the Newport Highres-2 USAF slide, JMC Scientific Consulting Ltd, April 16, 2022

3.3 SEM Imaging (Ground-Truth Reference)

The HIGHRES-1 target was imaged using scanning electron microscopy to provide definitive ground-truth resolution. The SEM clearly resolved all features down to **137 nm line/space**, validating the physical dimensions of the pattern.

Because the 137 nm elements are below the diffraction limit of visible-light optics, SEM is the established method for confirming true resolution. The SEM image serves as the performance benchmark against which SMAL and 100× objective images are compared.

Source: Newport website

4. Results

4.1 SEM Reference

- Fully resolves all groups and elements, including **137 nm features** (Figure 1)
- Provides precise verification of line width, spacing, and edge definition
- Establishes the physical limits of the target

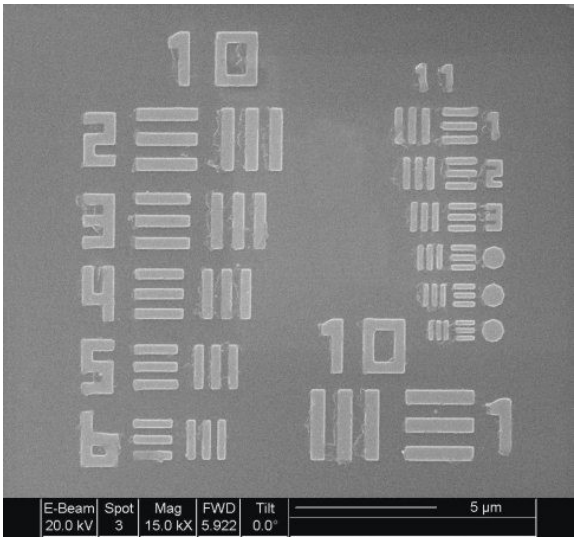

Figure 1: SEM image of the Newport HIGHRES-1 sample target

4.2 Standard 100× Objective

- Resolves features down to **~150–200 nm**, depending on wavelength (Figure 2)
- **Group 10** and **partial Group 11** resolved under UV and white light
- **137 nm features remain unresolved**, appearing blurred or merged
- Confirms the classical diffraction limit for conventional optics

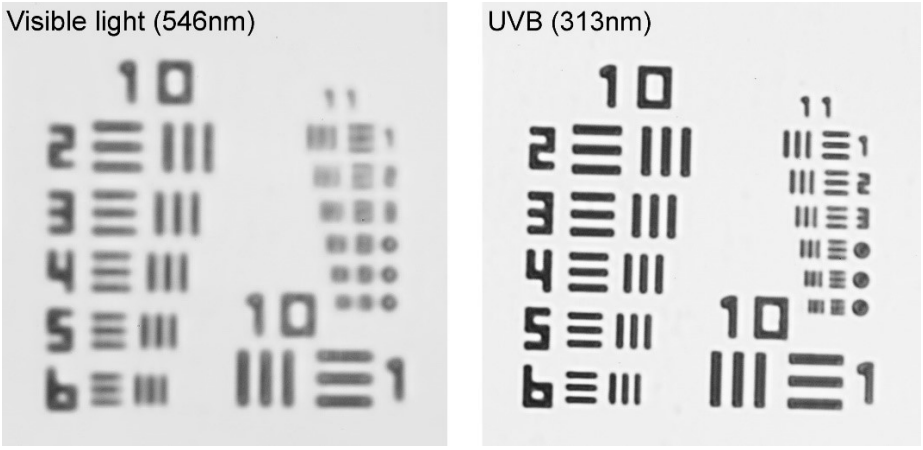

Figure 2: 100x immersion objective lens optical images of the Newport HIGHRES-1 target sample imaged in Visible Light (left) and UV (right)

4.3 SMAL Lens Performance

- **Clearly resolves the 137 nm features** (Group 11, Element 6)
- Distinct line/space separation with measurable contrast
- Resolution performance closely matches the SEM reference
- Demonstrates true super-resolution capability beyond the 100× objective

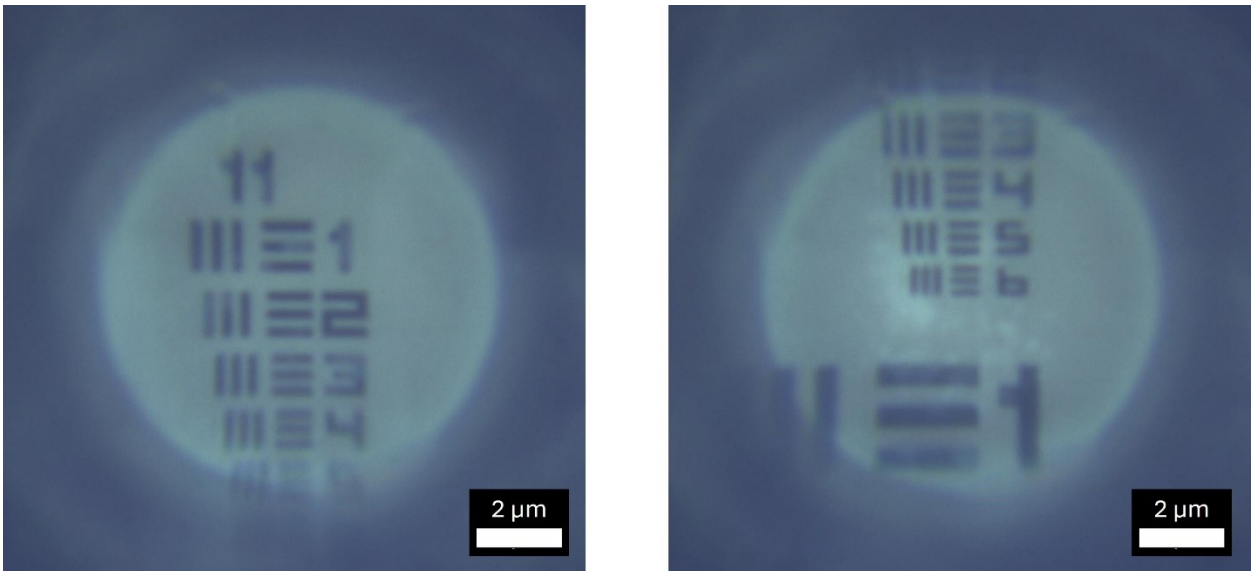

Figure 3: DRY SMAL image of the Newport HIGHRES-1 target sample

5. Comparative Summary

System	Smallest Resolved Feature	Group 11 Element 6 (137 nm)	Notes
SEM	137 nm	**Resolved**	Ground-truth benchmark
100× Objective	~150–200 nm	**Not resolved**	Diffraction-limited
SMAL Lens	**137 nm**	**Resolved**	Super-resolution

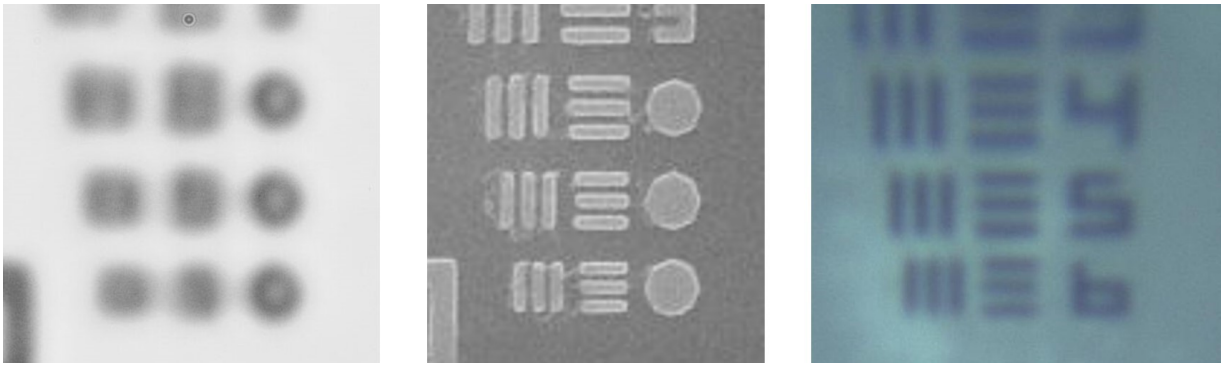

Figure 4: Comparison of the three-imaging method: left: 100x immersion, center: SEM, right: DRY SMAL

6. Conclusion

Using the Newport HIGHRES-1 target, the LIG-Nanowise SMAL lens demonstrates **verified super-resolution imaging** by resolving the smallest 137 nm USAF features—performance comparable to SEM and significantly superior to a conventional 100× objective. This establishes the SMAL lens as a powerful tool for nanoscale imaging in materials science, semiconductor inspection, and nanofabrication quality control.