

WinCamD Camera Use with Microscope Objectives

Introduction

WinCamD cameras may be used with microscope objectives to perform near-field re-imaging. For example, to magnify and re-image an LED/Laser facet or a beam waist. This can be an affordable solution to imaging beam waists that are too small to be measured directly, or are inaccessible such as at the output of a fiber. A microscope objective is not the only solution to measuring small and inaccessible beam waists—there are also [scanning slit beam profilers](#) for direct measurement of very small beams, and re-imaging [LensPlate2](#) accessories for inaccessible beams. But for beams that are both very small (<10 μm diameter) and require full 2D imaging, using a microscope objective with a camera is often the best solution.



Figure 1: MO-5x objective on the WinCamD-LCM mounted using the WCD-MOM microscope objective mount.

Mounting Schemes

Standard microscope objectives conforming to the RMS (DIN) standard require a total optical distance of 150 mm between the objective's RMS threaded mounting flange and the objective's image plane. This ensures working at their design optical distances corresponding to optimal imaging.

With WinCamD cameras, the image plane must coincide with the detector array which is located ~ 7.5 mm below the surface of the case for the WinCamD-LCM (other models sensor plane to surface distance vary). The suggested arrangement is shown in Figure 2.

The camera saturation power will be m^2 higher than the curves shown in the [User Manual](#), where m is the objective magnification. If the calculated power means that you will not need to use the ND-4 filter, replace it with the additional spacer ring.

If you need to hold the front end near the objective for mechanical stability, the WCD-MOM kit includes a mounting ring with 1/4-20 thread.

Parts List

- WinCamD-LCM or other WinCamD model camera
- **WCD-MOM** - Microscope Objective Mount
 - (1) 111.5 mm C-mount tube
 - (1) 15 mm C-mount tube
 - (2) 5 mm C-mount tubes
 - (1) 6 mm External C-mount to internal DIN adapter
- MO-XXx Microscope objective: MO-4x, MO-10x, MO-20x or MO-50x. Please specify your wavelength when ordering.

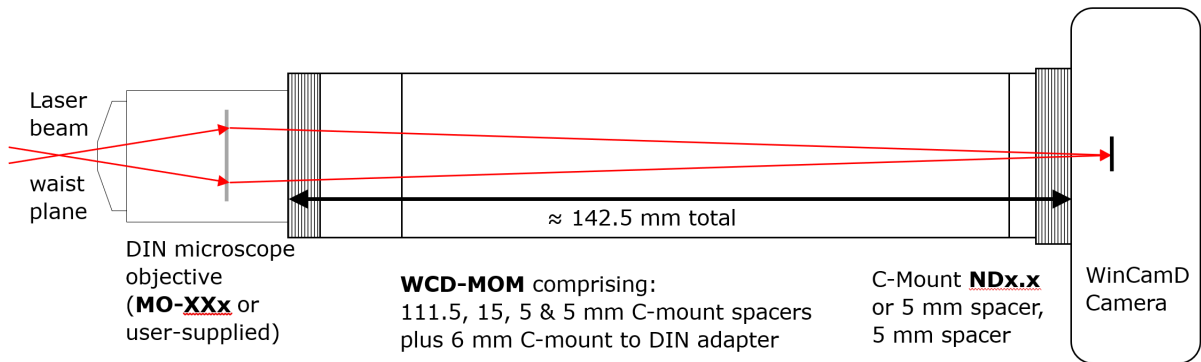


Figure 2: Mounting of a DIN microscope objective to WinCamD camera using the WCD-MOM.

Alignment and Mounting

Stability

For an objective magnification m , the alignment difficulty is frequently a factor of m higher than the measurement would be with no magnification. Take care to ensure that the camera plus objective system is solidly mounted. At high magnifications, even vibrations from acoustic, mechanical noise, and vibrations of air-conditioning systems can cause poorly mounted systems to resonate.

Diffraction-limited performance

If the flange to image plane distance is substantially different from 150 mm, the imaging will degrade from diffraction limited in some un-quantified matter which is worse at higher magnifications. Also, the beam should be aligned such that the center is on-axis. When in doubt, re-image a high resolution grid pattern to determine the quality of the imaging.

Focusing

The source is in focus when the magnified diameter is at a minimum. Move the source or camera in Z to set this. This must be set correctly before measuring the lens magnification as detailed below.

Lens Magnification Measurement

The software can compensate for known magnifications by entering a value in the **Pixel Multiply Factor** (PMF) box in the **Capture Setup** dialog (**Setup**→**Capture Setup**).

Follow these steps to complete the magnification measurement:

1. Align and focus the system
2. Click in the **Centroid [absolute]** box until it switches to **Centroid [relative]** and the **Xc**, **Yc**, and **Rc** boxes reset to 0.
3. Move either the source or the camera plus lens assembly a known transverse distance and measure the transverse change in the position of the image centroid on the screen. Using the relative centroid feature, this will be calculated automatically as **Rc**.
4. The ratio of the actual movement and measured centroid movement determines the pixel magnification factor. This should be entered in the Capture Setup Dialog as the pixel multiplication factor for both **X** and **Y**.

E.g. You move the source or camera laterally by 10 μm & the image centroid moves 400 μm . The pixel magnification is therefore $(10/400) = 0.04$. Enter 0.04 as the PMF factor for **X** and **Y**. The on-screen dimensions will then be correct.

Other Considerations

Limitations include pixel size, residual lens aberrations, lens NA limitations on collected light and resolution, and residual multiple reflections if the lens AR coating does not adequately address the wavelength(s) of interest.

Pixel Size

The first limit is the pixel size. The image and profile for a 50 μm beam in Figure 3 show that eventually the pixel size limits the accuracy with which the beam can be resolved. Please see our [blog post about small beam width error](#) for more information. We normally recommend the $1/e^2$ diameter of a beam to be at least 10X the pixel size. E.g., to image a 6 μm spot that requires at least 10 pixels across the 13.5% diameter, the WinCamD-LCM which has a 5.5 μm pixel size would require the beam to be magnified to at least 55 μm . For this measurement a x10 objective is good, x20 is better.

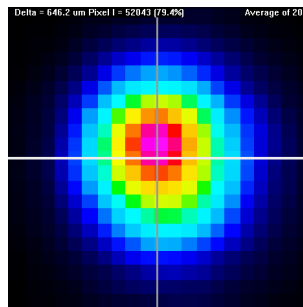


Figure 3: 2D Image of 50 μm beam on WinCamD-UCD12 Camera with 4.65 μm pixel size

Numerical Aperture

The second limit is the objective's NA. For an objective magnification m , the resolution in the 'object' plane will either be the pixel resolution $((\text{pixel size})/m)$ μm , or $(0.61 \cdot \lambda / \text{NA})$, whichever is larger. NA is the Numerical Aperture of the beam or

the microscope objective, whichever is smaller. Note that irrespective of the theoretical resolution, WinCamD interpolation allows the system to read out both beam dimensions and centroid position to 0.1 microns. On small beams, these can be quantized as coarsely as the sampling limit of $((\text{pixel size})/m) \mu\text{m}$.

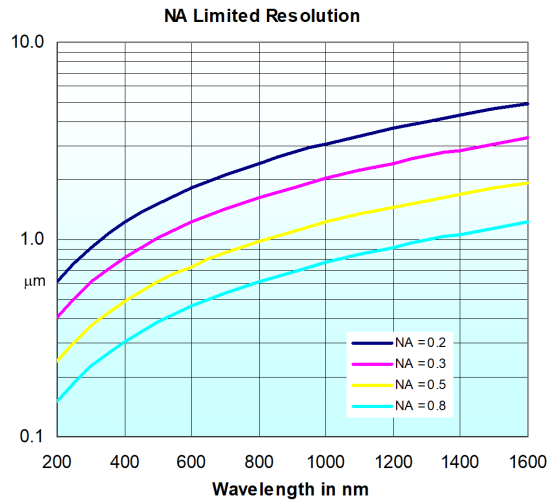


Figure 4: NA-limited resolution for various wavelengths and NA values.

Re-imaged Area

The imaged beam waist or facet area will be $((\text{sensor X dimension}/m) \times ((\text{sensor Y dimension})/m))$, where m is the objective magnification.

Filtering

In the **Filter** drop-down menu bar, it is important to select No Filtering when looking at small beams in order to avoid smoothing and broadening of the beam profile.

Alternative microscope objectives

- Buy the best objective that you can afford. i.e. Plan (Flat-field) or Semi-Plan rather than simple achromatic or 'standard' objectives.
- Ensure that the NA of the lens is sufficient for your application.
- Buy an objective coated for your wavelengths of interest.
- Infinity-corrected objectives do not form an image unless you add an ancillary lens.
- Avoid objectives that are cover glass corrected or 'Immersion' objectives.
- Most objectives use the RMS (DIN) mounting thread standard of 0.8" x 36 TPI. The JIS standard is the same thread but assumes a different tube length. Mitutoyo objectives use a 26 mm x 0.706 mm pitch thread.