Super-Resolution Microsphere Amplifying Lenses (SMAL)

Resolution Tests

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Resolution Testing

Pelcotec™ CDMS Calibration Standard

Using an official calibration standard, the super-resolution capabilities of SMAL can be demonstrated in standard brightfield microscopy on Nanoro.

The Pelcotec™ CDMS 0.1 T/C calibration standards (right) contains a set of lines with well defined centre-to-centre distances at a range of scales. There are approximately 10 lines in each size scale and the centre-to-centre distances range from 1.0 mm to 100 nm, with the gaps between being much smaller.

In the images below, the advantages SMAL has in colour, contrast and resolution is clear in comparison to the some of the best available 100x magnification, 1.25 numerical aperture oil immersion lenses.

SMAL allows sub-diffraction limited features to be resolved in full colour.

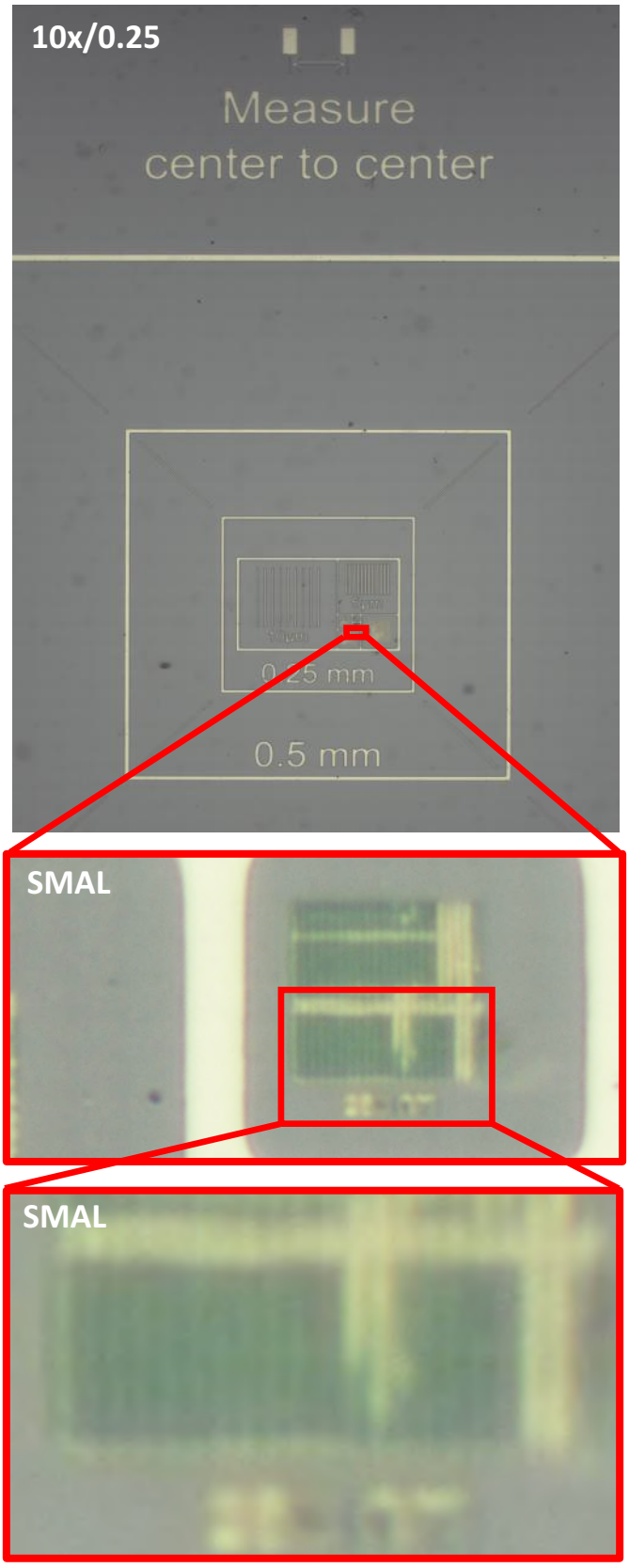

Figure 1. Critical Dimension Standard imaged by SMAL optics and best available commercial immersion optics.

Resolution Testing

Resolution – How Is It Defined?

The resolving power of an imaging system is quantified by the closest distance two parts of an image can be before they cannot be distinguished. Resolution is limited by the light used, and can be 350 nm for white light in a "perfect" system. One alternative method of measuring this is to measure the optical blurring across a sharp transition, taking the Full-Width at Half-Maximum (FWHM).

SMAL allows resolutions below 100 nm to be achieved. Figure 3 shows an average width of transition of 70 nm.

Here we define the resolution by the size of the region of transition between two different features of a sample.

Figure 2 'Object' shows a black sample (Feature A) next to a white region of a sample (Feature B). The transition between the regions is infinitely sharp on the 'Object', but when imaged the transition between black and white is blurred by the resolution of the system to create an image similar to that shown in Figure 2 'Image'.

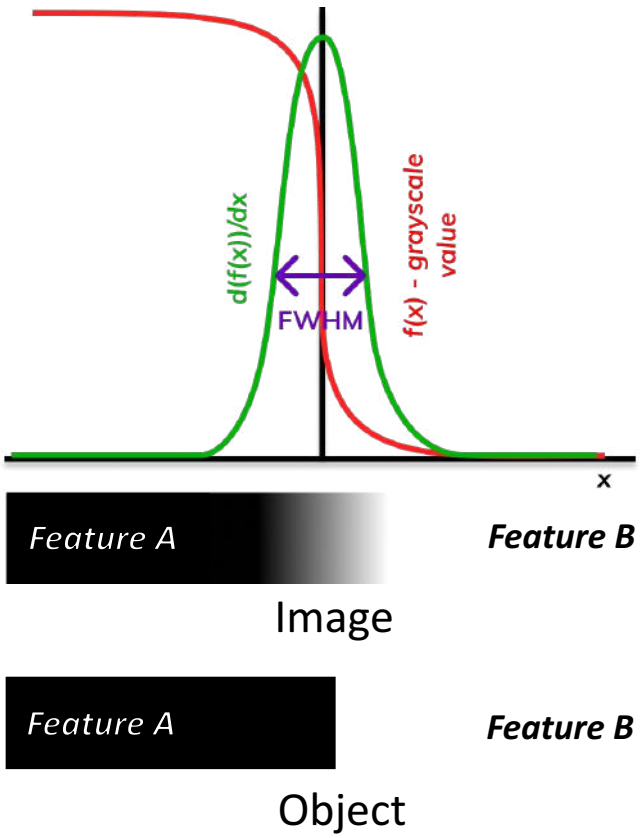

Figure 2. the limit of resolution of a microscope objective refers to its ability to distinguish between two closely spaced objects.

To define this resolution numerically, the differential of the grayscale value of the image is taken over the transition from dark to light and the **FWHM** of this function reported – green trace of Figure 2 (top).

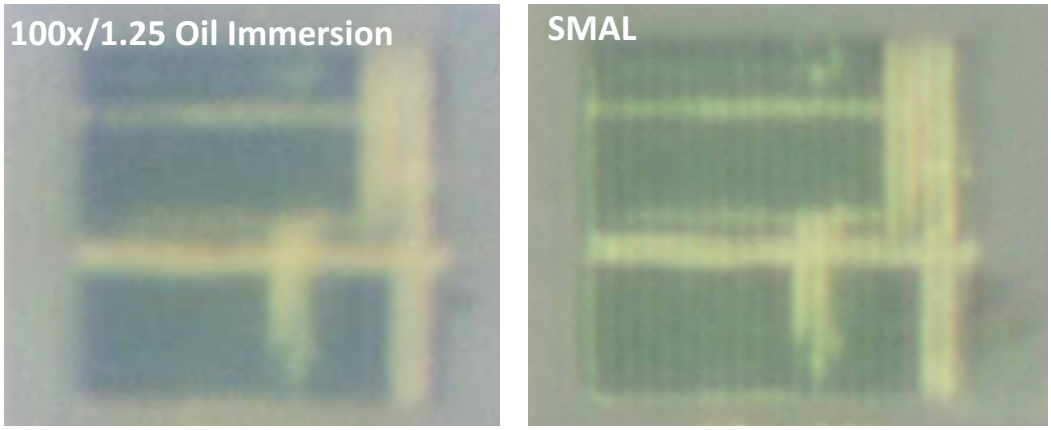

Figure 3. The gaps between the lines are estimated at 80 nm, considerably smaller than the 250 nm pitch of this area of the grid. These lines are only visible in white light microscopy using SMAL technology.

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