

## DinoLite Digital Microscope Performance

Eugene Cisneros

Mineralogical Research Company

The question has come up as to the technical competence and quality of the of the DinoLite line of digital microscopes. I am therefore responding to these questions based upon my observations and some facts. In this short note, I provide objective information that will serve to put into perspective the quality and usefulness of the DinoLite Digital Microscope as a serious instrument capable of being used for scientific purposes.

The mechanical design and construction of the DinoLite is rugged and well thought out. The most common construction has a high impact plastic body. A beautifully finished alloy body version is also available that adds a high end touch to the instrument, though the optics and electronics are identical to the lower priced high strength plastic version. All of the DinoLite models share the same co-axial focus control, which is very smooth and easy to use. Most models have a magnification range of 20:1, or more. The electronic design is robust and failures are very low at approximately 0.2%, by our experience.

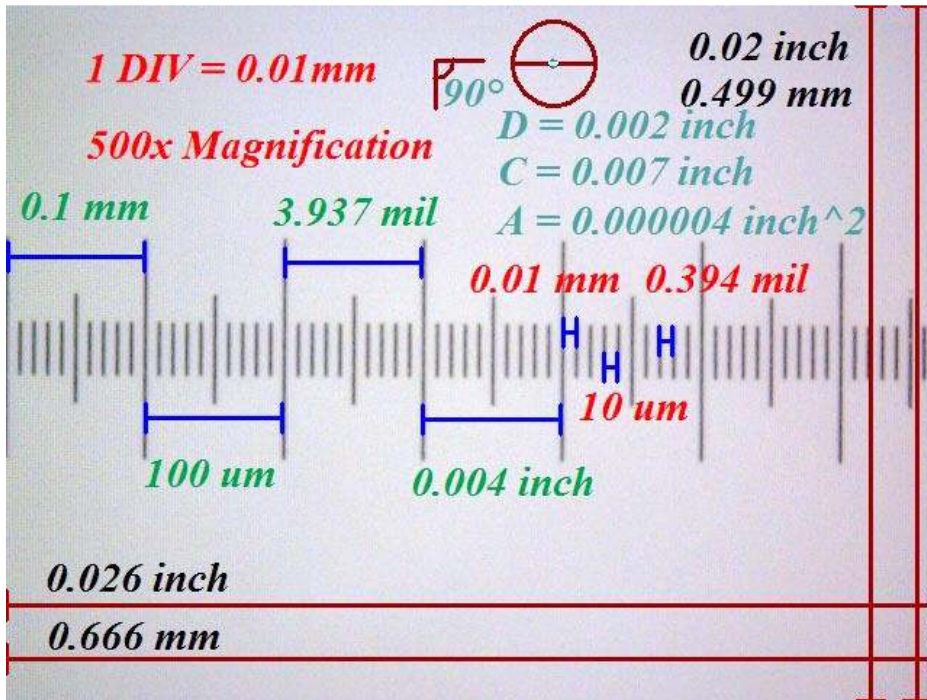
The most frequent questions and comments are regarding the quality of the optics and resolution. To answer these questions, I had to query the factory and perform some simple tests. Fifty different models of DinoLite Digital Microscopes are protected by U.S. Patent #7.112.817. Because other companies have tried to copy the DinoLite, proprietary information, such as lens design, number of elements and performance specifications were not available. What I was able to confirm, from the factory, is that the lenses are manufactured from optical glass and are multi-coated, as opposed to the plastic lenses that are used in the very cheap knockoffs that are available on the grey market. The questions regarding performance, notably resolution, had to be answered by test.

The following two paragraphs will help to understand the conclusions drawn later in this note, but are not necessary if you don't like the math. The resolution of any microscope is finite and a function of diffraction and the wave nature of light. Resolution is defined by  $R = \frac{0.61\lambda}{NA}$ , where R is resolution in nm,  $\lambda$  average wavelength of the illumination in nm and NA = numerical aperture of the lens. Numerical aperture (NA) is dimensionless and a somewhat better way to specify a lens, as it doesn't depend upon the wavelength of light, but only the geometry of the optical light cone.

The depth of field (D) of any microscope, with a numerical aperture in the range of ~0.05 – 0.3, is a function its resolution and is defined by:  $D = \frac{3.27R^2}{\lambda}$  From this it can be seen that depth of field is less for high resolution microscopes and greater for low resolution microscopes. That is, you cannot have both high resolution and large depth of field. For two microscopes, with the same NA, the depth of field will be the same at a given magnification. We strive for high resolution, knowing that depth of field suffers as a result. This is the nature of the relevant optical physics.

To compare the DinoLite's optical resolution with other microscopes, a somewhat crude measurement of resolution was made. This allowed for a simple calculation of NA, which could then be compared with that of microscopes of known high quality. To obtain a reasonable approximation of the resolution, a calibration slide with 10um tic marks was used. Unfortunately a finer graduated slide, such as a resolution standard, was not available, as they are extremely expensive. The DinoLite model with the highest magnification (AM413T5)

was selected in order to achieve maximum resolution. As can be seen in the photo, the 10um spacing between lines is cleanly resolved.

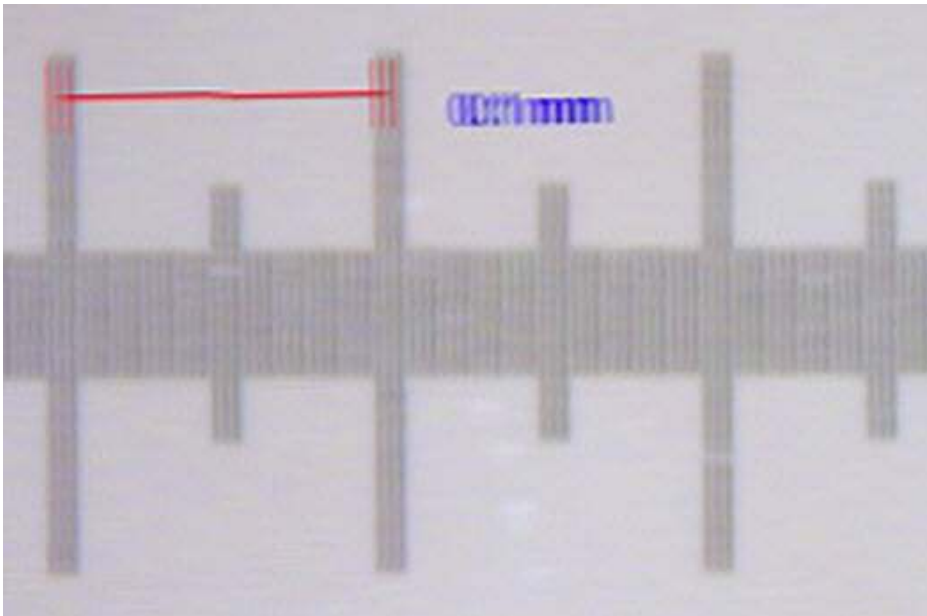


Reduced full frame image of test slide taken with DinoLite AM413T-5

It was conservatively estimated that, with finer line thickness, at least 3 subdivisions of the 10um tic marks could be resolved. That would equate to a resolution of approximately 3.3um, or 303 lines/mm. According to the Rayleigh criteria, the lines need not have clear space between them to be resolved, as long as they can still be discerned as separate lines. The numerical aperture can be calculated from the resolution.

$$NA = \frac{0.61\lambda}{R} = \frac{0.61 \times 550nm}{3300nm} = 0.1 \text{ or better.}$$

To assure that the above assumption is correct, a crop of the slide image was taken and offset to divide the 10um tic marks by thirds.



The shifted tic marks are clearly resolved, so the estimate originally made is very conservative. The resolution is actually higher than estimated, by Rayleigh criteria. Finally, an optical test was implemented to physically measure the entrance acceptance angle of the lens. From the measured acceptance angle the numerical aperture was calculated and found to be in agreement with the calculations above.

How does this compare with high end stereo microscopes? Nikon specifies their best stereo microscope objectives as follows:

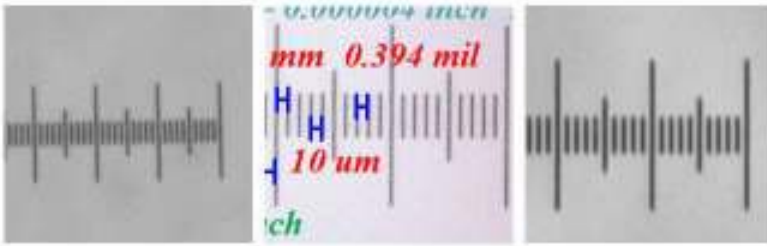
**Nikon Stereomicroscope Objective Specifications**

Objective Magnification	Color Code	Numerical Aperture	Working Distance (Millimeters)
ED Plan 0.5x	Red	0.045	155
ED Plan 0.75x	Yellow	0.068	117
ED Plan 1x	White	0.09	84
ED Plan 1.5x	Green	0.14	50.5
ED Plan 2x	Blue	0.18	40
Plan Apo 0.5x	N/A	0.066	136
Plan Apo 1x	N/A	0.13	54
Plan Apo 1.6x	N/A	0.21	24

From the table, the Nikon ED Plan 1X objective has an NA of 0.09, nearly equal to the DinoLite NA of 0.1. Keep in mind that higher NA results in higher resolution. The DinoLite has a resolution, of greater than 303 lines/mm, and is essentially the same as that of the ED Plan 1X objective. The highest resolution Plan Apo 1.6X objective is only better by a factor of 2.1. Under the best of conditions, the Plan Apo 1.6X can resolve 625 lines/mm. Consider that these objective lenses are used on high end microscopes and it becomes obvious that the DinoLite has very credible performance at a fraction of the cost.

Below are comparison images taken of calibration slides. The instruments used were the DinoLite AD413T, AM413T5 and a Nikon SMZ800 research grade stereo microscope, respectively. The center image was taken of a different slide than the other two and has thinner lines. However, all of the images have 10um minor gradations, so the spacing is the same for all three scales. All of the images, which are small parts of the original images, were taken at the maximum magnification of the instrument. A 1.3MP camera was used on the

Nikon scope to match the sensor size used in the DinoLite. It is hard to dispute the similar performance shown in the last two images.



Note: The color balance was not set properly in the center image.

DinoLite AM413T    DinoLite AM413T5    Nikon SMZ800  
ED Plan 1X

A look at the reduced full frame of the test slide will give some measure of the very good field flatness and lack of geometric distortion that is inherent to the DinoLite optical system. Chromatic aberration (color fringing) is very good out to the edge of the field.

Finally, some mention has been made as to the superior optics of the Raynox add on macro attachment lenses for digital cameras. In fact, Raynox specifies a resolution of 340 lines/mm for their add-on lenses alone, which is very good, but is reduced to 200 lines/mm when used in conjunction with a required camera lens.

The simple tests described here were performed to provide objective data with which to judge the level of performance that can be expected from the DinoLite and that it is of sufficient quality and precision to qualify as a serious and capable scientific instrument. Here are a few demo images, illustrating a range of applications.



