

Using a Sony Cyber-Shot Digital Camera for Photomicrography

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Introduction

Photomicrography is the combination of photography and compound microscopy. Photographers working with compound microscopes are facing many challenges (for an introduction see [1] and [2]). Digital photography offers great advantages, but also adds additional difficulties. Digital cameras have been used in photomicrography for over a decade now. Today, we have access to many excellent consumer-grade digital cameras that are most suitable for low-cost imaging systems for light microscopy. In this short paper, I summarize my experience with the Sony DSC-S70 digital camera, which comes with a nice, large Zeiss lens. (Most of the ideas presented in this paper are also valid for the DSC-S75 and DSC-S85.)

Many of the published reports I could find about this topic suggest using a Nikon Coolpix 990 (or 995) camera. This Coolpix model has a smaller front lens than the DSC-S70, which is often used as an argument for choosing this Nikon camera. – I have a Coolpix 995 with a Nikon MDC relay lens that does not outperform my Sony DSC-S70 when connected with a “homemade” adapter to the same Nikon MDC lens.

In 2000, with the introduction of the DSC-S70 [3], Sony surprised the competition by using a lens system designed by Carl Zeiss labs. This lens system, called a Vario Sonnar, produces very reasonable images. It is a bright, F2.0 lens system. The DSC-S70 has a maximum resolution of 2048×1536 pixels with an image ratio of 4:3.

A Closer Look

There are essentially three different ways to operate this Sony camera to take pictures through a microscope. The first one, a very primitive and unsophisticated way to take pictures, is to use an eyepiece with a rubber ring (called ocular guard), which is intended to avoid scratches on eyeglasses. Using such a protected eyepiece, the lens of the DSC-S70 can directly be placed on the ocular. It is recommended to hold the camera firmly with one hand and use manual focusing. With some practice, it is possible to take quite reasonable images with this simple setup (see picture 1 for an image through an eyepiece with 20 mm field of view (FOV)).

The second possibility, is using an adapter that directly mounts the camera to a regular eyepiece. This is particularly recommended if the optical setup requires a compensating eyepiece to fully correct for lateral chromatic aberration. Nikon's CF and CFI60 objectives are corrected for lateral chromatic aberration without assistance from the eyepiece. I have not tried this setup with my DSC-S70, but it is very similar to the third setup, where the camera is mounted on a phototube. The use of a phototube offers the most stable configuration and helps greatly to avoid vibration. I am using manual focus and aperture priority mode with the lowest possible aperture setting (depends on the zoom setting). I adjust the brightness of the illumination to ensure that the camera sets exposure time to be 1/100 second or faster. This fast exposure time avoids “dangerous” exposure times, usually between 1/50 second to 1 second [5].

I am using a trinocular phototube that has a 38 mm ISO port. The choice of camera fell on the DSC-S70 since I already owned one. To connect this camera to the microscope, I use a photo-relay lens from Nikon, called an MDC lens. I got this lens with the Cool-



Picture 1: “Freehand” image of human kidney, t.s. of cortical zone, through standard eyepiece (20 mm FOV) using 40x objective.

pix camera and had only to craft a simple connector to fit it to the DSC-S70. I will explain all parts in the next section entitled “The Individual Parts.”

Let's look at some more details of the DSC-S70. The CCD of the DSC-S70 is 1/1.8" in size (diagonal 8.933 mm). It is a frame readout CCD image sensor with square pixel for color cameras. Its designation is ICX252AQ. This silicon, solid-state image sensor has RGB primary color mosaic filters with a unit cell size of 3.45µm (H) by 3.45µm (V). This sensor also supports Sony's Super HAD CCD technology (HAD = Hole-Accumulation Diode).

The A/D conversion is done with a resolution of 12-bit. The Carl Zeiss lens system goes from 7 – 21 mm (34 to 102 mm equivalent) with an aperture of F2.0 to F2.5.

The Individual Parts

In this chapter, I introduce all necessary parts to connect a Sony digital camera via a Nikon MDC relay lens to a C-mount adapter mounted on a phototube.

One of the disadvantages of this particular consumer electronics camera is its non-removable lens. Because of this, the photographer cannot mount this camera directly on a C-mount but will require a converter lens that is very similar to an eyepiece. I chose Nikon's MDC relay lens designed for the Coolpix 995 camera. It has a C-mount thread (see picture 2).

The MDC lens is a very expensive lens (over \$600). Most certainly, there are less expensive ways to mount a low-cost digital camera to a microscope. But the principles are very similar. A commercially available relay lens for the DSC-S70 with a C-mount thread costs around \$400 [6]. But remember, such a relay lens is a special part. It is not sold in high volume. Therefore, the price for a reasonable converter or relay lens is pretty high. Furthermore, it is a lens that might not be frequently used by professional photographers working in the field of photomicrography. When professional photographers use digital cameras on a microscope, they mostly prefer an image sensor with a CCD that has a great quantum efficiency and low noise but comes without a built-in lens system. There are many companies that produce great CCD's (such as Sony and Kodak). A good specialized CCD camera for photomicrography can easily cost more than \$5000 (without a lens!). But the prices are really coming down. There is a cheaper alternative to a CCD camera sold by Vitana Corp (see <http://www.pixelink.com/>), called the PixelLink PL-A642

Sample In — Knowledge Out

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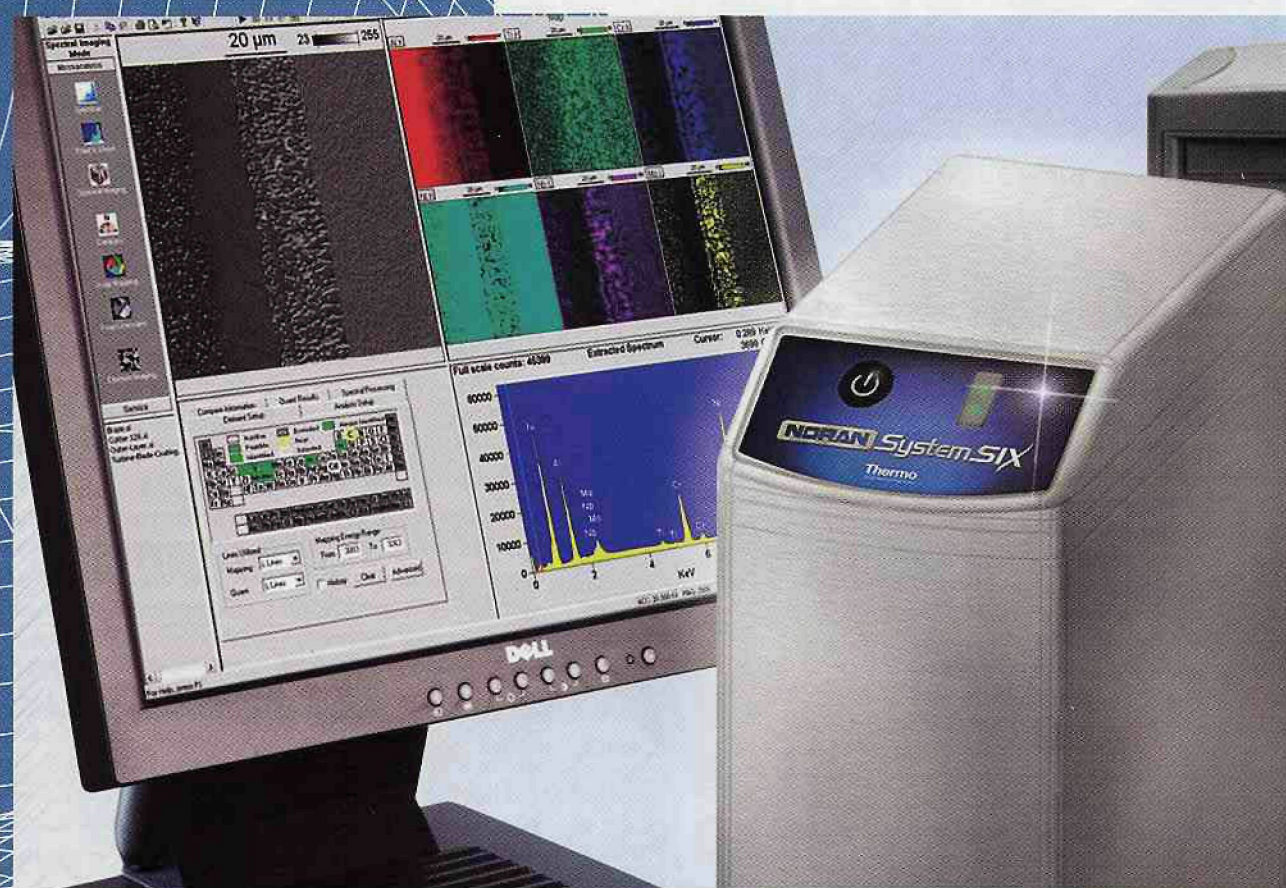
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Picture 2: (Left) Nikon MDC relay lens (part number 82014). The small ring located on the left side of this picture had to be removed. The field of view (or field number) of this lens is 18 mm.

Picture 3: (Center) Parts for this setup. Picture on left side shows Y-T TV tube with 1.0x C-mount, VAD-S70 adapter and MDC lens with "homemade" adapter ring. Picture on right side shows all parts connected.

Picture 4: (Right) Dimensions of "homemade" adapter. The image below shows the small ring that must be removed from the MDC lens.

FireWire camera. This camera has a CMOS sensor, which offers a decent resolution. However, currently available CMOS sensors are much noisier than CCD's. So far, I do not know of any high-end digital camera that uses CMOS image sensors [7].

I use a trinocular tube E2-TF for a Nikon Eclipse microscope. It has a 38 mm ISO port. Connected to this port is a Nikon ISO 38 mm Y-T TV tube with a D10NLC 1.0x C-mount adapter from Diagnostics Instruments. It is important to mention that the 1.0x C-mount has no built-in lens system. It is just a simple connector, which costs around eighty dollars. The Nikon MDC lens connects to this 1.0x

C-mount adapter. The whole setup is parfocal with the rest of the microscope, which means that once the image is in focus, I can look through the MDC lens and no refocusing is required.

A "homemade" connector is mounted onto the Nikon MDC lens. (In the next paragraph, I will describe this connector in more detail.) Finally the other side of this "homemade" connector is connected to a Sony VAD-S70 adapter, which can be purchased from Sony for \$35. This adapter allows using 52 mm filters with the DSC-S70, DSC-S75, and DSC-S85. After the camera is connected to the VAD-S70 adapter, the setup is complete. – To summarize, I required the following seven parts: Nikon trinocular viewing body, Nikon TV-tube, 1.0x C-mount adapter, Nikon MDC lens, "homemade" connector, Sony VAD-S70 52 mm filter-adapter, and Sony DSC-S70 digital camera (see picture 3).

What is this "homemade" connector? – When looking at the bottom part of picture 4 (right side), the reader can see a thread of 6 mm height. A 3 mm ring has already been removed to increase the threaded boarder to 6 mm. This 3 mm ring is replaced by a larger disk of aluminum with a diameter of 52 mm and a thickness of 3 mm. The aluminum disk has a threaded aperture in the center that just fits the thread of the MDC lens. This disk can easily be mounted inside the frame of a 52 mm filter-holder. I selected a filter-holder for a polarizing filter since such a filter-holder allows me to conveniently adjust the orientation of the camera. I had to make sure that the front-lens of the MDC lens is close to the front-lens of the DSC-S70 but does not touch it for all zoom and focus settings. For my camera, a 3 mm thick disk lets the Nikon MDC lens come sufficiently close to the front-lens of the DSC-S70 when using a standard filter-holder.

If you are using a DSC-S75, or even a DSC-S85, please ensure that this works for you! To find out how far the MDC lens can stick out, one could mount this "homemade" disk onto the VAD-S70 adapter, without a Nikon MDC lens, and measure the distance carefully. To measure this distance, I put the camera into the zoom/focus position where the lens sticks out the most. Then I used a Q-tip, slightly wetted with Windex, and stuck it into the aperture of the aluminum disk until it touched the lens. Pressing the Q-tip towards the thread of the aluminum disk marked the side of the Q-tip, which allowed me later to measure this distance with a ruler. See picture 4 for an illustration of the geometry of this setup.

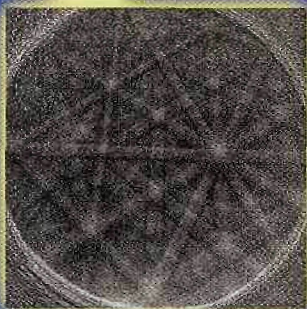
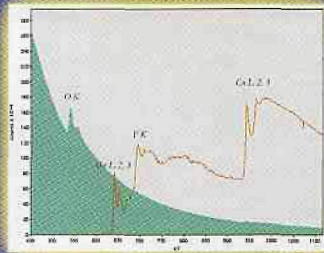
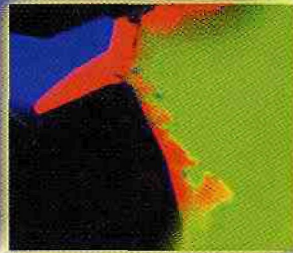
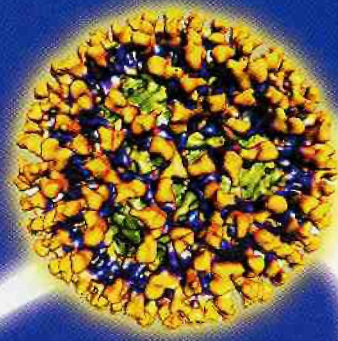
This Setup in Action

Photomicrography with a digital camera is a complex topic. It requires great care. Many tricks and recommendations, which



Picture 5: 100 diatoms forming a beautiful rosette (10x objective). Klaus Kemp made this exhibition slide in 2001.

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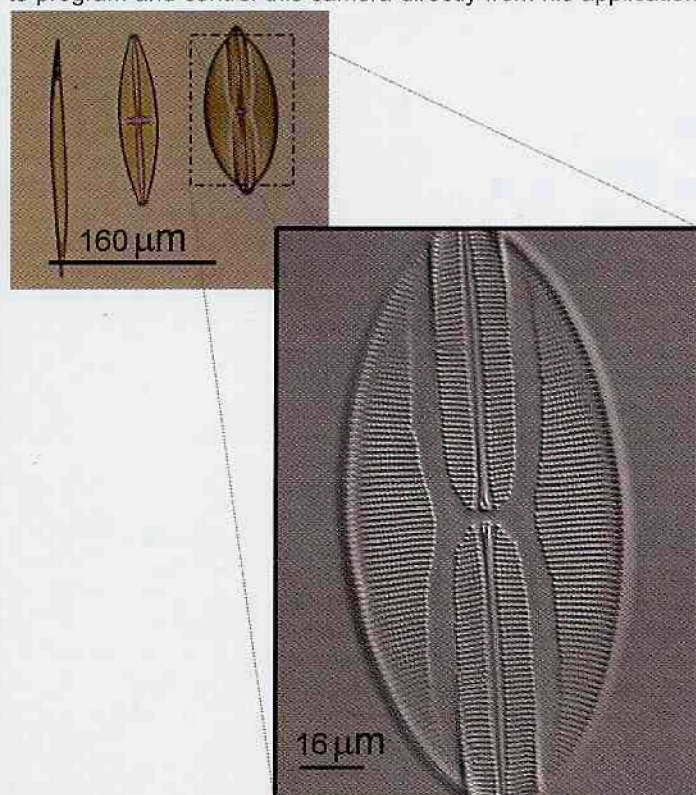
apply to "analog" photomicrography (see [1] for more information), are valid for digital photography as well. But there are major differences. CCD and CMOS image sensors have their unique properties (such as wave-length dependencies, quantum efficiency, resolution, contrast, etc.). I am not going to talk about this in this short paper. For me, the best resources currently available are various web sites. Quite often, it is required to post-process the digital image to enhance, but not to change, its contents. Fine programs to do this are PaintShop Pro 7 from JASC [8] and ImageJ from NIH [10].

Two of my favorite slides are a human kidney slide using a modified Masson's Trichrome stain and an exhibition slide by Klaus Kemp that shows 100 diatoms [11]. The diatom slide shows *Coscinodiscus*, *Didymosphenia Geminata*, *Paralia Sulcata*, *Trinacria Inspiciens*, *Biddulphia*, and *Aulacodiscus Kittoniae*, which are most perfectly arranged to form a rosette (see picture 5).

The healthy human kidney section is shown on the cover of this magazine. This kidney section is rather thick, which makes it more suitable for lenses with a lower numerical aperture, such as achromats [9].

From all these images, it becomes very obvious that the Sony DSC-S70 camera has enough pixel resolution to be useful for simple photomicrography. The analog to digital (A/D) conversion per color channel seems to be adequate. However, as it was expected from a low-cost non-cooled CCD, the performance is moderate. Compared to analog cameras using color films (such as Fuji Velvia), the DSC-S70 offers significantly lower contrast.

I encountered a couple of limitations with the Sony DSC-S70. First, I was not able to control the camera directly from a computer. There is no software interface available that will allow the user to program and control this camera directly from his application.



Picture 6: Diatoms from "diatom test plate 8 forms", see [4]. *Nitzschia Sigma*, *Stauroneis Phoenocenteron*, *Navicula Lyra* with 10x objective (small image), and *Navicula Lyra* with 40x objective (large image).

Second, it is very difficult to focus the image with this camera, as the reader might be able to see from some of the pictures. Focusing is very cumbersome with this camera. Especially when using lenses with high numerical aperture, the job of controlling image focus is very difficult [9]. This situation improves when using a digital camera that can be controlled from a high-resolution computer display. In this case, one can focus the image on the computer display. With the DSC-S70 camera, one must control the focus using the small display of the camera. The auto focus did not work for me and I had to switch to manual focus. An example is illustrated in picture 6. (It was quite difficult to focus exactly on the center of *Navicula Lyra*.) – Third, the quality of these pictures does not even come close to what I am used to when looking directly through the microscope. But this "subjective impression" is mainly based on the fact that any camera is very different from our eyes. For all performance studies of optical systems, the observer's characteristics (such as his eyes and his physiology) should be included [12].

In spite of all these disadvantages, I am pleased by this camera's resolution and ease of use. Having access to images shortly after taking them is very useful. It is a great tool that helps to communicate information between microscopists. The reader can find many reports about using a Nikon Coolpix for photomicrography [13]. Using a Sony DSC-S70 makes a lot of sense, but it is much more difficult to find information about mounting such a Sony camera to a light microscope. ■

Acknowledgements

I want to thank Dr. Jean-Luc Truche for many stimulating discussions. My thanks also go to Dr. Jerry Dowell who provided some valuable suggestions.

References

- [1] Fred Rost and Ron Oldfield, *Photography with a Microscope*, Cambridge University Press (2000). See chapter 17 about digital, confocal and video techniques.
- [2] Werner Nachtigall, *Exploring with the Microscope*, Sterling Publishing Co., New York (1996).
- [3] One year after the introduction of the DSC-S70, Sony introduced the DSC-S75. At the time of writing, the S75 is still sold by Sony. It has the identical CCD and lens system and can therefore be used in place of the DSC-S70.
- [4] This diatom test plate with 8 different forms is purchased from Carolina Biological Supply Company, 2700 York Rd., Burlington, NC 27215, US (see <http://www.carolina.com/>).
- [5] See page 62 in [2].
- [6] Adapter sold by Micro-Tech Lab (<http://www.micro-tech-lab.de/>). The adapter is called LM-Scope digital adapter #DASC70 (made in Austria). I have not used this adapter and do not know how well it performs.
- [7] But things might change soon (see http://www.foveon.com/X3_tech.html to find out more about the "first" full-color image sensor).
- [8] PaintShop Pro is currently sold as version 7.04 by JASC (see <http://www.jasc.com/products/psp/>). It cost slightly over 100 dollars. It requires Microsoft Windows operating systems.
- [9] Depth of field (DOF) is the area in front of and behind the object that is in acceptable focus. The depth of field is inversely proportional to the square of the numerical aperture. DOF depends on the wavelength.
- [10] ImageJ is provided by the National Institutes of Health, US, and requires a JAVA virtual machine. It is available at <http://rsb.info.nih.gov/ij/> free of charge.
- [11] Klaus D. Kemp has a web page at <http://www.diatoms.co.uk/>.
- [12] Vasco Ronchi, *Optics – The Science of Vision*, Dover Publications, Inc., New York (1991).
- [13] Theodore M. Clarke, Fitting a Student Microscope with a Consumer Digital Camera, *Microscopy Today*, 02-3 (2002), and references therein.

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