An Illuminated Stage

Richard J. Nelson

A microscope is like a good car, it should be powerful and strong. Unlike a car, however, a good microscope needs an assortment of accessories which, in some cases, may be more expensive than the microscope itself. Many simple accessories may be assembled from everyday items and most microscope users improvise in one way or another.

I bought three USB Microscopes at the 2011 CES Show in Las Vegas, and I have been evaluating them - see Fig. 1.

As with most product categories you will find a full range of designs – cheap to robust. Electronics technology also gets added to the mix when USB microscopes are considered. You may spend less than $100 or you may spend over $1,000. It was the CES "show specials" (low end) that prompted me to evaluate these three USB microscopes.

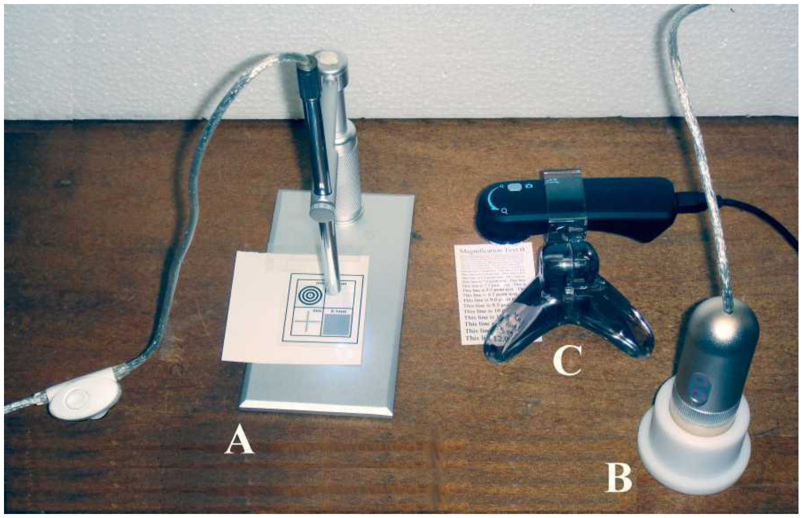

Fig. 1 – My three 2011 CES "show special" USB microscopes. See Appendix A for additional details.

The three designs are shown at the right. Each one has its unique advantages and disadvantages.

As a technical writer I frequently need to include photos of small items so I thought that perhaps having a small simple USB microscope handy might make capturing small subject images easier. The image quality of these designs are getting better each year and the highest resolution design I saw at CES (expensive) was 5 megapixels.

My Nikon stereo microscope and Sony 10.2 Megapixel DSC-TX1 usually handles most of my small subject image requirements. In the "old days" this would be called macro photography – where the subject image is one to ten times larger on the film.

During this evaluation project I was walking through Lowe's Hardware when I noticed an UnderCabinet Fluorescent Light hanging on a shelf. It is three inches in diameter, operates on 117 VAC, is one inch thick, and costs $8. It is a nine watt "replacement" light and I bought one with the idea of using it as an illuminated stage. See Fig. 2. As a replacement bulb it was intended to "plug into" a fixture as shown at the center right in the photo. I didn't see the fixture.

Fig. 2 - Fluorescent light replacement.

See the unpackaged photos in Figs. 3a & 3b. The small fluorescent tube covers most of the internal space. The top is a soft rubber like plastic that that slightly defuses the light. The plastic wasn't easily removable and I didn't want to damage it by tearing anything. See more on this later. The oily like surface won't allow tape to stick to it. I was concerned that the starter or ballast would be part of the fixture that it plugs into, but I took a chance and indeed it is a completely contained light. Its convenient small size allows it to be put under most microscopes for stage (back) lit applications.

Fig 3a – Front of fluorescent bulb replacement.

Fig 3b – Back of fluorescent bulb replacement.

All that is needed is to add an AC power cord and I happen to have a power cord cut from a discarded lamp. It has an in-line switch as shown in Fig. 4. The power cord is soldered to the two terminals and insulated with (red) heat shrink tubing. See fig. 5.

With the attachment of the power cord the illuminated stage is ready for use. Two improvements could be made, however. The first

Fig. 4 – AC power cord to be soldered to the lamp.

Fig. 5 – Soldered power cord is insulated with heat shrink tubing. Bend flat while hot.

Fig. 6 – Black paper reduces extraneous light. Note the color differences. It is really more of a warm white.

improvement is to tape a piece of black paper around the outside to reduce extraneous light. See fig. 6. The second improvement is to cut/drill several pieces of white paper and translucent plastic to be placed on top to make the light more even and to slightly color correct the light from the warm fluorescent to make it cooler.

One of the applications I have is to photograph coins. Lighting is always a challenge and you don't want any shadows around the edges. Of course you may remove this with post image processing, but why not just do it right? One method of doing this is to back light the coin. See an example in fig. 7a. The USB microscope camera lighting is turned off and only the overhead lighting provides a little visible image on the most reflective coin. When the USB microscope lighting is turned up the coins are nicely lit. These images were made with the USB microscope "C" in Fig. 1. These "microscopes", with lots of example images and a discussion of limitations will be discussed in detail in other articles.

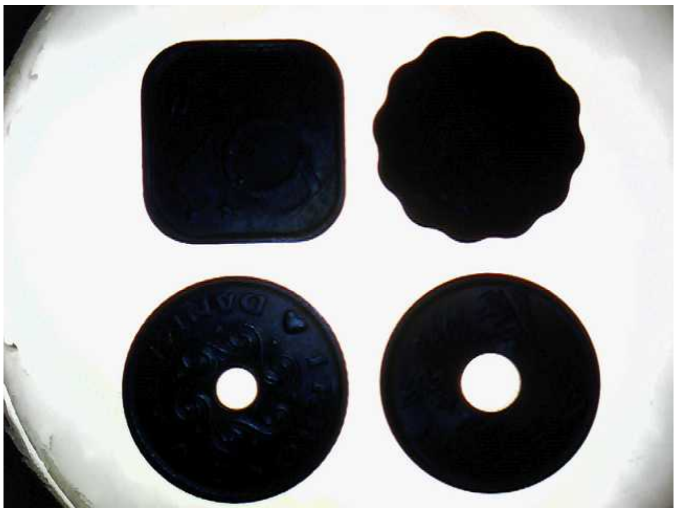

Fig. 7a – Back lighting only shows the silhouette.

Fig. 7b – Low back light and full microscope LED light.

I cut two sheets of copy paper into 3-1/2 inch squares and I stack them up to control the intensity of the back light. Nine sheets were used for Fig. 7b.

My stereo microscope is often used to examine subjects such as 35 mm film. See figs 8 & 9.

Fig. 8 – Illuminated stage on Microscope.

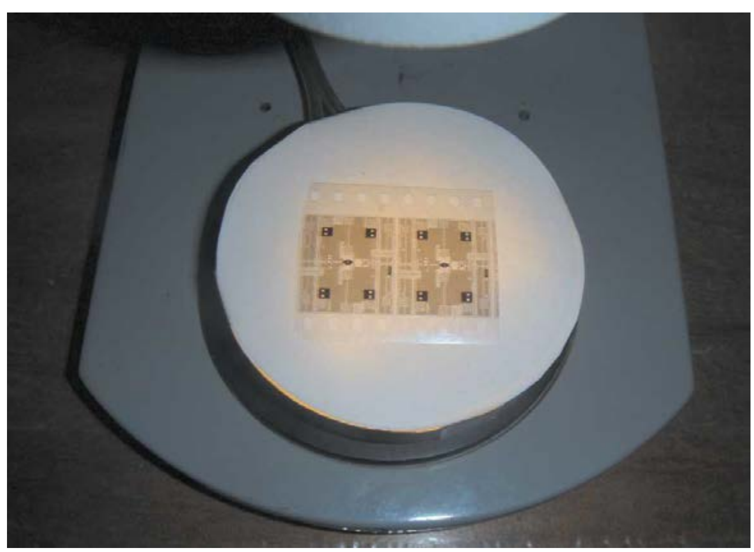

Fig. 9 – 35 mm film is back lit for a sharper image.

Fig. 10 shows images of the 35 mm test film at various magnifications. The background is not a pure color and is due to the paper or plastic used to defuse the light. I am still looking for a proper pure white plastic diffuser.

The small squares in Fig. 10 are 0.10 mm on each side. The magnification shown in Fig. 10c is 10x. A larger version is shown below in Fig. 11 with an effective magnification of 30x.

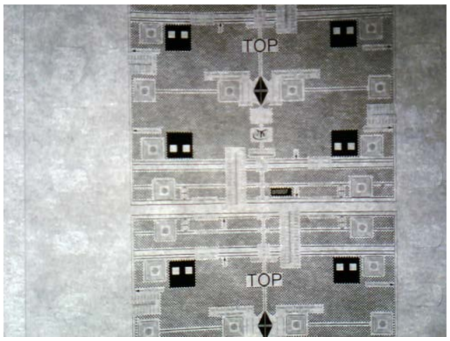

Fig 10a – 35 mm test film.

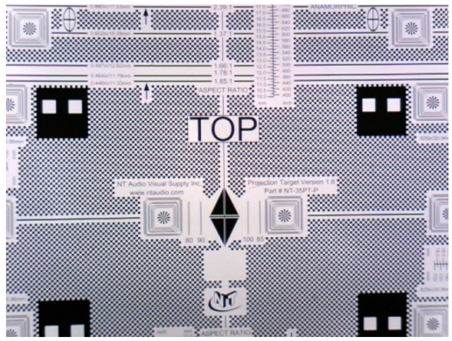

Fig. 10b – 35 mm film enlarged.

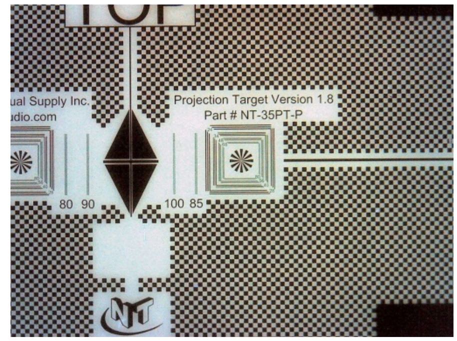

Fig. 10c - 35 mm film enlarged more.

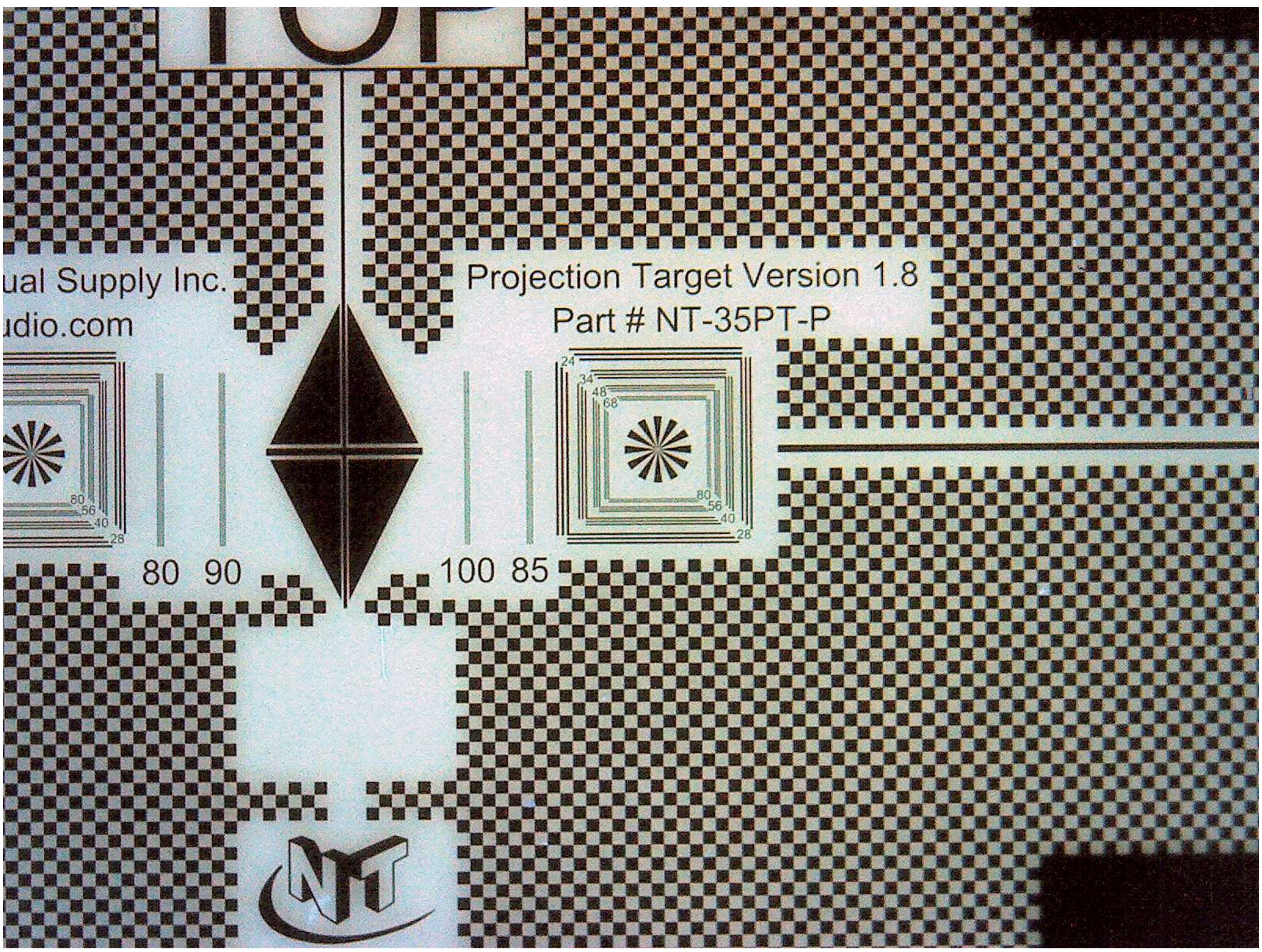

Fig. 11 - Same image as Fig. 10c enlarged further. The magnification here is 30x. Each square = 0.10 mm.

Observations and Conclusions

The $8 UnderCabinet Fluorescent Light sold at Lowe's Hardware makes a nice illuminated stage for general microscope use. Its size is just about perfect for both microscope and macro photography use. While it only consumes nine watts it may heat up with long extended use. This is obviously an accepted design feature because there are no ventilation holes. I started drilling a hole in the side but decided that until I could remove the cover for a better look at the space inside I shouldn't just drill randomly.

Another important technical challenge of the UnderCabinet Fluorescent Light is the plastic light diffuser. I used two different types, copy paper and circles cut from a four foot Acrylic lighting panel found at Home Depot. A pure white version was not found at my local Home Depot, Lowes, or Ace hardware. Perhaps a lighting store will offer what is desired. The primary purpose of this article is to provide some illuminated stage ideas.

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Epilog

After visiting several stores I couldn't find a workable solution, but an Internet search provided all kinds of options if you search for "white acrylic diffuser." Dimensions/specifications are scarce and you have to order a large amount of material. Typical light attenuation is sometimes described as ½ Stop for at least one product.

I did find a solution, however, at Big Lots that works well, is low cost, and easy to cut. I bought a white 18 Qt. Dishpan, 8" x 13" x 15" made by United Solutions for $2. I cut several 3-1/2 " squares. The thickness is 0.070". Fig. 10a was repeated using the more white and uniform material. Two thicknesses of the material were used. See Fig. 12.

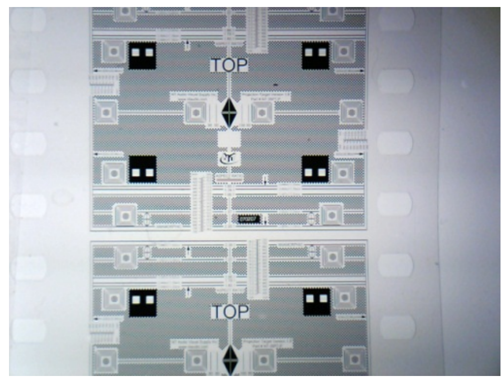


Fig 12 – 35 mm test film on new diffuser.

Using plastic close to any heat source will cause slight buckling and bending so this is the primary technical limitation of this illuminated stage. Drilling air vent holes would help. In practice you simply address this limitation by turning it off when not actually using it.

Another idea for an illuminated stage is to use the head assembly of a milti-LED flashlight. It could be battery operated, the cost would be much less, the diameter could range from 1" – 3" and it certainly would not generate any significant heat. The time and work, however, would be much greater. Fig. 13 shows a $1.50 assembly that runs on 4.5 VDC, measures 3/4" of an inch in "diameter", and 1/2 inch in thickness. It is more than bright enough. A simple series resistor "pot" could provide a very nice brightness control.


Fig 13 – LED assembly.

Building an LED Illuminated Stage

A reviewer of this article thought that having an adjustable illuminated stage would be an important accessory so the idea of using an LED flashlight assembly as shown in Fig. 13 was investigated.

A new 99 Cent Only Store opened last week and I visited to see their new stock. I bought a dozen $1 LED flashlights and removed the 9 LED assemblies using a tubing cutter to remove the top portion of the aluminum case. See Fig. 14. I used nine even though I planned on using seven in a six-around-a-center layout.

Fig. 14 – 9 LED flashlights from 99 Cent store.

The leads of the LEDs are bent abound the circuit board and make pressure contact with aluminum tube. You MUST push the assembly out towards the switch end. The assemblies easily fit into the cap, see Fig. 15, with room for a slice of cardboard (back of a tablet) to be cut to make an internal tube for another cap to be used for the upper half of the illuminated stage. Since the LED leads are no longer connected they need to be wired. I used 24 Ga. Wire from an old telephone cable. See Fig. 16. The wire adds to the diameter and is also used to solder them together as shown in Fig. 17.

Fig. 15 – 7 LED assemblies fit in a plastic mustard cap.

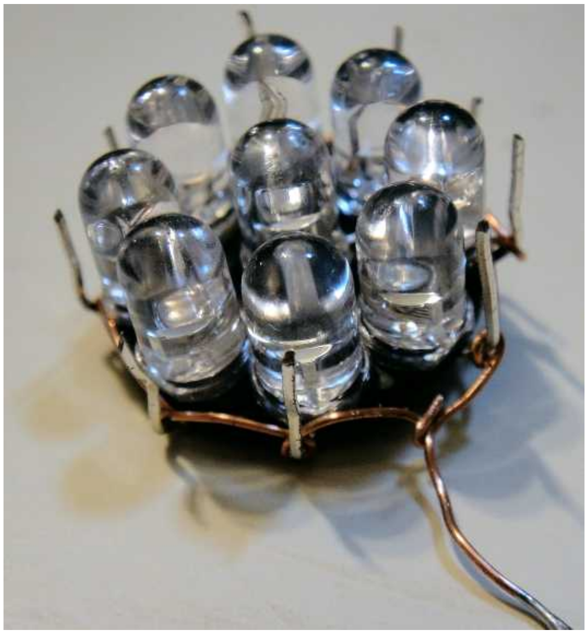
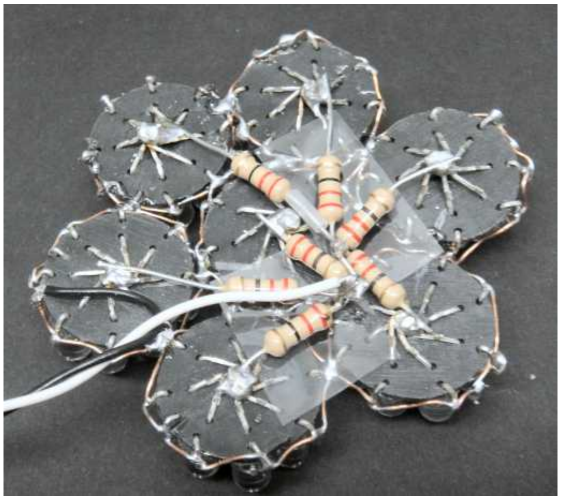


Fig. 16 – Negative leads need to be wired & cut.

All LEDs in each flashlight assembly are connected in parallel. LEDs need a current limiting resistor and cheap flashlights depend on the internal resistance of the battery. They are very bright, but their life will be greatly reduced by a factor of as high as four – 25,000 hours vs 100,000 hours. I wanted to keep the current to a reasonable level. A typical LED of this type is 0.02 amperes. Sixty three of these would require 1.26 amperes of current.



F 17 – Current limiting 22 ohm resistors.

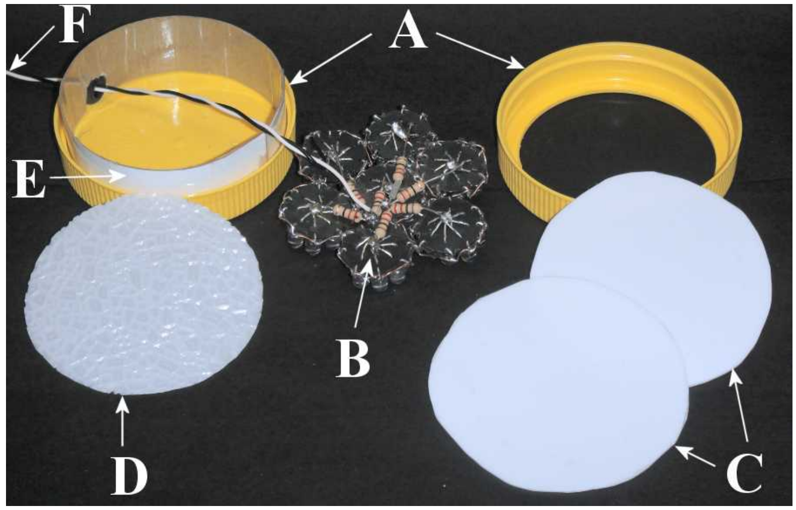


Fig. 18 – Parts for the LED illuminated stage.

I wanted to use a battery power supply. The flash lights used three AAA cells each or 21 total. I decided that using D cells would provide portability and reasonable life. At 4.5 volts, 63 LEDs, and 22 ohms the total current is 0.31 amperes. This was based on testing a single flashlight assembly and adjusting the brightness using the USB UM-CAM microscope. I included the three diffusers in determining the brightness requirement. If I were to use an AC adapter for power I would probably use 6 - 10 ohm (1/2 watt) resistors. When it comes to microscopes you can always use more light. If you do need more light with the 22 ohm resistors use 4 D cells to operate at 6 VDC instead of 4.5 VDC. Fig. 18 shows the competed illuminated stage. The materials I used are:

A. Two mustard jar covers.
B. Seven flashlight LED assemblies soldered together and wired with 22 ohm ½ watt resistors.
C. Two diffuser sheets cut from Big Lots white 18 Qt. Dishpan, UPC 145 170018069 2 060.
D. “Course” fluorescent light diffuser, rough side up. Available at Home Depot and Lowe’s.
E. Cardboard strip 0.95” wide trimmed length wise for a tight butt fit.
F. Stranded wire leads four feet long to the 4.5 – 6 VDC power supply. A rubber grommet hole is drilled in the bottom mustard cap and cardboard sleeve as shown.

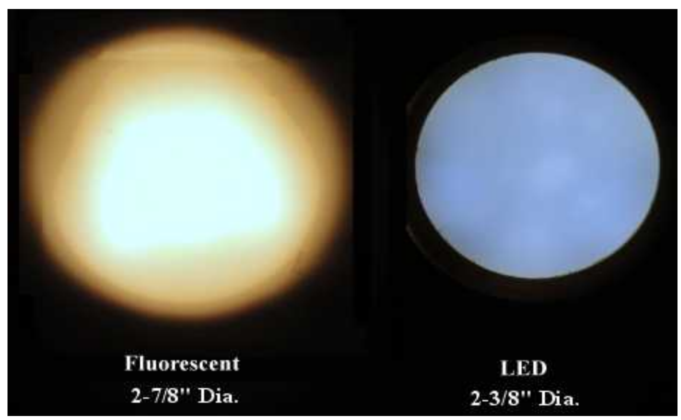


Fig. 19 – Two illuminated stages compared.

Fig. 19 shows the fluorescent lit stage compared with the LED lit stage. Note the color difference. Two Big Lot dishpan diffusers were used on top for each in addition to a third diffuser in the bottom.

Fig. 20 shows the two stages built to test the USB microscopes. Fig. 21 shows a D cell power supply for the LED stage. It provides 4.5 VDC to power the 63 LEDs in the stage. The 500 ohm variable resistor varies the current to the illuminated stage from a minimum of 5.6 mA, to 6.9 mA when the first visible light is seen to 320 mA at full brightness. A red LED was used for a power-on indicator and it is in a hole drilled in the post that holds the two Fahnestock clips used for connecting the power leads to the stage. I selected a very efficient red LED from my junk box that would provide a visual ON/OFF in normal light at a current of 52 microamperes. I wanted an especially efficient indicator so that the D cells wouldn't be drained if I left it on and not connected. All parts were from my junk box except the battery holders. The power switch was from one of the flashlights. It works quite well. See Fig. 22.

Fig. 20 – Two illuminated stages compared.

Fig. 21 – Stage variable power supply.

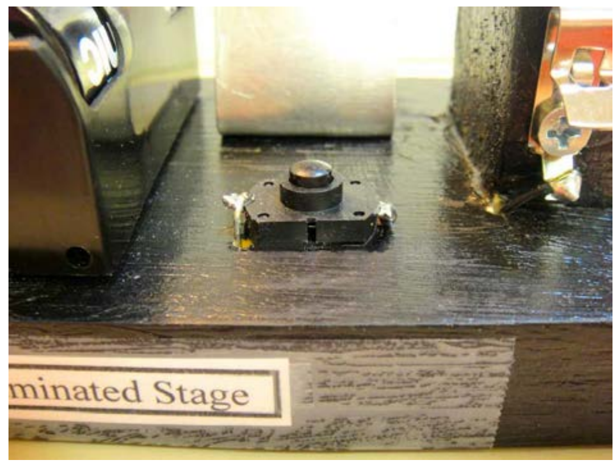


Fig. 22 – Flashlight Power Switch is used.

Both stages work very well. The LED stage was made to have a variable light output which is essential for optimum lighting. It is thicker than the florescent lamp version because a greater space between the first and second diffuser is more effective in providing a fairly uniform light as shown in Fig. 19. The camera really picks up the subtle differences in uniformity that the human eye doesn't see.

LED Diode Considerations

LEDs are current operated devices and require current regulation for proper (long life) operation. The simplest regulator is a series resistor. LEDs vary greatly in performance in terms of light brightness for a given current and they are selected (graded) by most manufacturers so that arrays of LEDs will look uniform in brightness and color. The value of the series resistor is not critical, but it should be selected properly (for ohmic value and power dissipation value) to meet your design requirements.

If the diffuser is effective it is easy to make an illuminated stage of any size using the construction method described. If a larger area is desired a larger cap could be used.

Final Observations

I changed the cardboard inner tube to a strip of the same plastic of the diffuser in order to increase the strength. When I did this I made it 1" wide which made an increased space (improvement) between the upper and lower diffuser. The LED illuminated stage works very well with a full dark to maximum brightness provided by the 500 ohm variable resistor. Lighting is critical for use of the USB microscope.

Appendix A - Details of Microscopes Shown in Fig. 1.

CES 2011 had several USB microscope vendors showing their latest USB microscopes. The leader and most expensive of these is Big C of Torrance California. (www.bigc.com). These tend to be the most expensive and they have a tremendous assortment of products and accessories. Their website has 15,000 example images so you may get a good idea if a particular microscope is suitable for your purpose.

I purchased two Able Eye USB microscopes at CES 2011. These are the following.

Fig. A1 – Here is a higher magnification microscope that has a nice fully adjustable stand.

Below are the specifications of the eheV2-USB-Splus USB microscope. Note how the magnification is specified. For practical purposes divide the magnification given by any USB microscope supplier by at least factor of ten or 20 to bring it closer to a normal microscope specification. The photo and the specifications are copied from the Manual provided on a small sized CD supplied with the microscope. When I saw this at the booth I questioned the magnification numbers and the demonstrator asked me what I thought the magnification was on the large LCD screen. I estimated it at less than 20 not 200.

TECHNICAL SPECIFICATIONS - **eheV2-USB-Splus**

1. DSP: High Quality Digital Image Monarch Processor.
2. Sensor: high-quality CMOS sensor
3. Resolution: 1600X1200
4. Interface: USB2.0.
5. Frame rate: 30 frames/sec (CIF and VGA).
6. Focal distance: 5mm - infinity
7. Magnification: 200× (at 5mm FOCUS and display on 17” screen by 1600X1200 resolution)
8. Diameter: 8.2mm
9. Length: 110mm
10. Timing snap: 10 seconds

The second Able Eye USB microscope I bought as a show special is more like a true microscope. It is the $150 EHEV3-USBUV and it has a fixed magnification that I would rate more as 40x rather than the 50x specification given on the next page. Because this product is intended to be pressed against the skin it is “fixed” in its magnification. I made a very simple modification to what is provided to make it work more as expected in terms of a more conventional microscope. My magnification estimate is based on the photographs I have taken using a 0.10 mm grid (film) shown on the stand of USB microscope “A” shown in fig. 3. I have a silver/pinkish colored version.

Fig. A2 – This is a special handheld white & uv lighted USB microscope with a constant magnification.

This is my favorite of the three because it is switchable between white and ultraviolet (375 nm) illumination. Full details may be found in my articles dedicated to these USB microscopes. See the specifications from the manual below.

TECHNICAL SPECIFICATIONS - EHEV3-USBUV

1. DSP: Digital Image Monarch Processor.
2. Sensor: high-quality CMOS sensor, 2M pixels
3. Resolution: 1600×1200
4. Colors: true color 24bit (RGB)
5. Interface: USB2.0.
6. Frame rate: 30 frames/sec (CIF and VGA).
7. UV excitation wavelength 375nm
8. Magnification: 50×
9. Size: 32mm in diameter, 92mm in length
10. USB cable length: 1.8 meters
11. Image freeze: just rap space bar
12. Timing snap: 10 seconds

The third USB microscope I bought is from Microlinks Technology Co., Ltd. It is called the UM-CAM and has been around for more than a year. It comes supplied with a stand that allows it to be used as a microscope and a webcam. For the $60 show special price it is really quite a bargain and comes closest to the handy computer desk microscope/webcam that I thought I would investigate. I bought it because of several improvements made compared to last year's model. See Fig. A3.

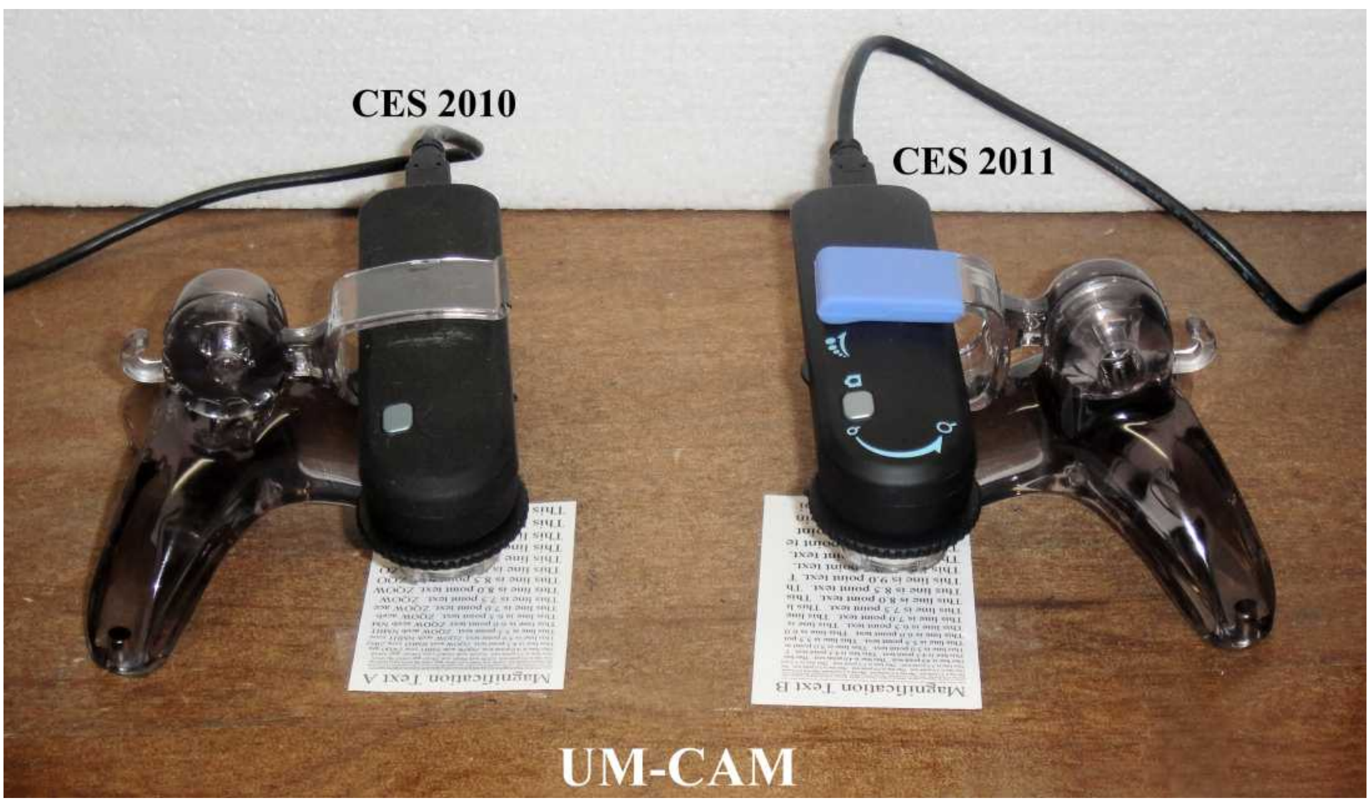


Fig. A3 – USB microscope/webcam for general use up to 45x (printed landscape). The legs have NIB magnets.