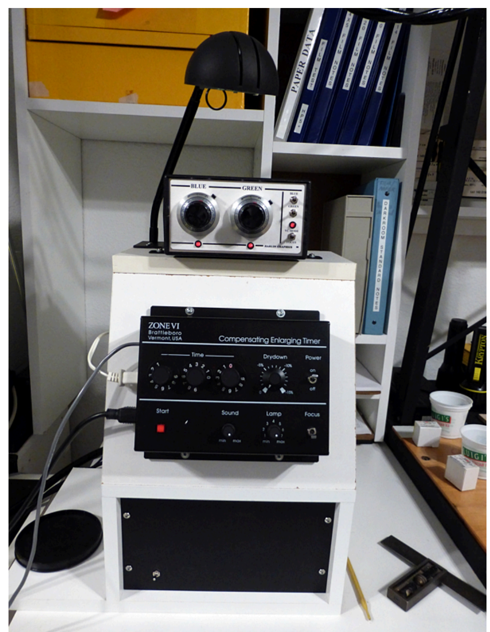
DESIGNING & BUILDING AN LED VC ENLARGER HEAD

There are projects and then there are PROJECTS! I have had this idea in the back of my head for several years. The idea that someday there would be an LED technology that would allow you to build a stable Variable Contrast Head for enlarging and printing on VC Papers. Up until now, about the only way to achieve continuously variable contrast control with an enlarger was to either use a dichroic color head or a dual grid cold light. Either works very well, but they all have their trade offs. Trade off is an old engineering term for; you do the best you can with what you have available at any one time.

New rebuilt 8x10 enlarger with LED VC Head.

I have never used a dichroic color head for printing. . . never owned one. But I have years of experience using the dual-grid Neon versions. I have highly modified both the Aristo and Zone VI models to suit my needs. They work and they work very well. Thing is, with Neon you have a continual problem with light stability. The stability problem is somewhat controlled by heaters installed in the head that attempt to keep the Neon grid lamps at a constant temperature. This does work, to a degree, but you still get drift. You have to use some sort of compensating device to get consistent exposure. We use a Zone VI Compensating Enlarging Timer. It uses a sensor to measure the light output and speeds up or slows down the timer as needed. Works, but is annoying.



8x10 LED Control box, timer and power supplies.

As technology advances one would think that eventually there would be an LED technology that would work. I have been watching the advances in LED technology for some time and I finally had a confident feeling that the time is finally right! We had an executive meeting and determined that mounting a new project to explore the feasibility of building a VC enlarger head using LEDs should be attempted. So, here is what happened over the last few months. . .

DESIGN GOALS

There were several design goals that we agreed would be important to achieve.

- replace the heavy neon head with something lighter and possibly smaller
- get rid of heaters in the head
- get rid of heavy high voltage transformers
- build a light source that has reasonably consistent light output
- design a light source at least 1 stop brighter than the current neon head
- make the diffuser as large as possible
- achieve the same contrast range as the neon VC head being replaced
- hopefully pull this off and make it work!

LED TECHNOLOGY

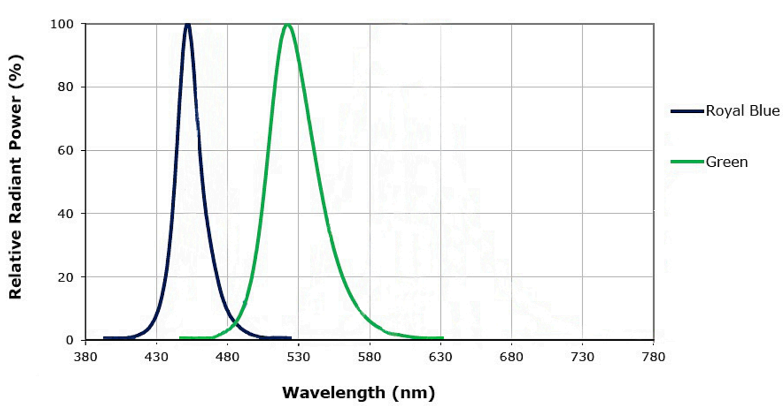
The basic technology and design of modern LEDs has made many quantum leaps in the last 20 years. The new high-power LEDs emit a near terrifying amount of light and consumes very little power doing so.

An LED is a semiconductor that is designed so they emit light when a voltage is applied. By using different chemicals, the LED can be constructed to emit different colors of light. The first LEDs were made in the 1950's and 60's and were gradually designed to emit everything from infrared to green light. . . but getting to blue proved to be a challenge. Blue required certain chemicals and carefully created crystals that took some time to learn to make.

High-power LED.

BLUE LEDs

The hardest nut to crack for those designing LEDs has been coming up with a blue LED. Early blue LEDs looked blue to the eye, but spectral analysis shows there was a lot of green also. Green is not what you want in a VC enlarger head if you want to print high contrast. Early attempts at using LEDs for VC printing yielded poor results in achieving high contrast. It should be correct to assume that the green content in the light from these early LEDs would limit just how much contrast you could attain printing on VC papers.



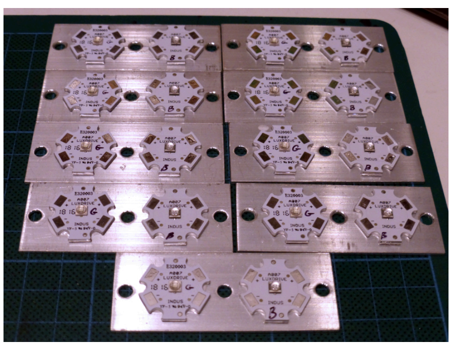
Royal Blue and Green LED spectral output.

The good news is a few years ago technology finally caught up and the first really true, pure blue LED came on the market. If you look at the published specs, you will find there are two colors of blue LEDs now available. There are Blue and Royal Blue colors and there is a difference. The Royal Blue LEDs have a narrow spectral output very akin to blue neon. Take a look at the spectral graphs.

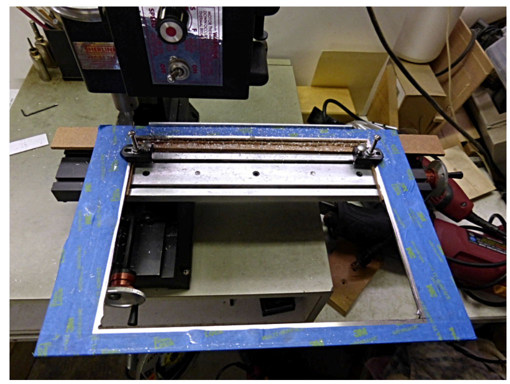
Now that we have finally gotten there and a truly blue LED is a reality, is should be possible to design a full-range VC printing head. Though we are talking about blue LEDs, it should be mentioned that green LEDs for low contrast printing on VC paper is not a problem. In my test experience, it is easy to achieve contrast well below grade #0.

BUILDING A PROTOTYPE

There is only so much you can do when designing something new reading manufacturer's specs and using a computer with CAD. The time comes when you have to start machining metal, soldering and testing. The necessary components were obtained and it was just a matter of wiring things together and making them work. The idea was to attach a green and blue LED to a length of 0.75" wide by 0.125" thick aluminum stock. The LEDs were glued to the aluminum using thermal epoxy glue. Nine assemblies were made up and they were arranged in a predetermined pattern on the top plate of the head. The top plate is a 0.125" thick sheet of aluminum 10.50" x 15.00" and serves as a heat sink for the LEDs.



Blue and Green LED assemblies.



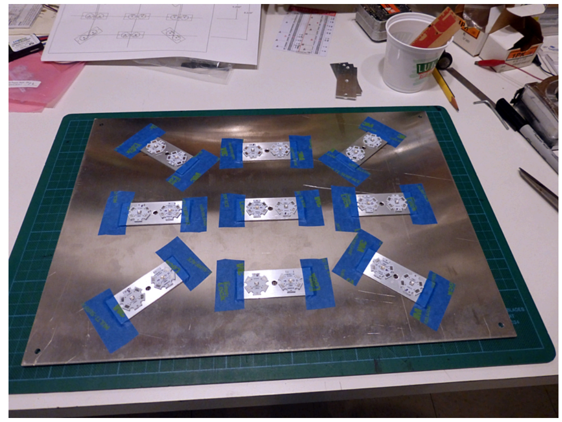
Machining the cutout in the bottom of the head for the diffuser.

Top and bottom assembly, with diffuser installed, on 8x10 enlarger.

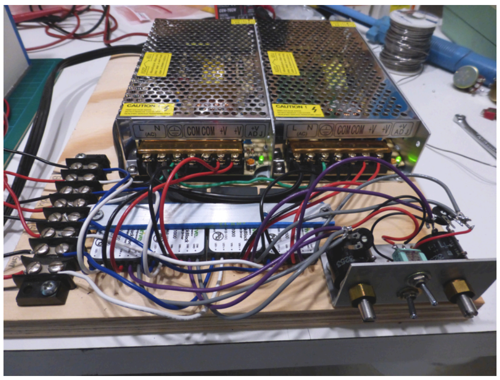
A second sheet of 0.125" aluminum was machined with a cutout of 9.00" x 11.50" to form the bottom of the head. Then a 0.250" thick sheet of acrylic diffusion material was cut and machined to fit the opening. One of the design objectives was to make the diffuser as large as possible. Even illumination is more likely assured if the diffuser is larger than the film. In this case, 8x10 and 4x10 film are the only sizes used with this enlarger, so there is ample illumination available.

Machining the diffuser.

The LEDs selected are Cree XLamp units in Royal Blue and Green. These LEDs operate at a maximum current of 1,500ma for the blue and 1,000ma for the green. The drivers used were 1,000ma LUXdrive BuckBlock LED drivers. These units were chosen because they can easily dim the LEDs and have a fast response time for turn-on and turn-off. It was determined that one BuckBlock could not drive all nine LEDs so the load was divided to 5 LEDs on one and 4 on the other. This means there are 4 BuckBlocks in the controller. The dimming function was implemented using a 10-turn potentiometer, one on the blue LEDs and the other on the green. This gives precision control of the amount of green or blue light and hence the contrast range possible when printing. This is the exact same arrangement used in the modification to the existing neon dual grid units, but that is another story unto itself.



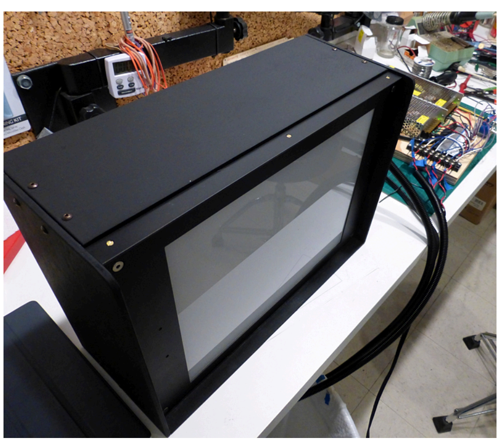
LED assemblies taped to upper heat sink for testing.



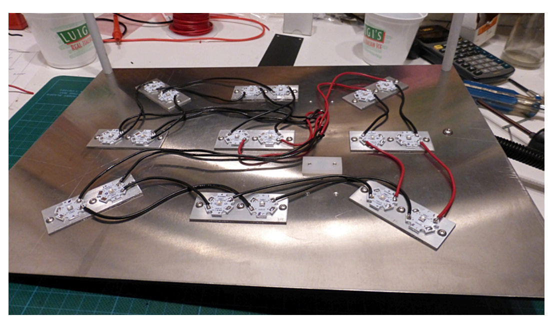
Breadboard LED power supplies and controllers.

It was decided to use two DC power supplies, one for the green and one for the blue LEDs. The supplies chosen were 5A supplies and one could have been used for both, but I like overkill.

The head was assembled, the LEDs arranged, temporarily taped in place and wired. The spacing between the top and bottom was predetermined from the beam-width and spacing of the LED assemblies. Spacers were machined and the basic head was inclosed with foam core. A quick breadboard controller was wired up and the rig was ready for testing.



Complete 8x10 LED head enclosed, painted and ready to install.



Top heat sink with LED assemblies mounted and wired.

TESTING FOR HIGH CONTRAST

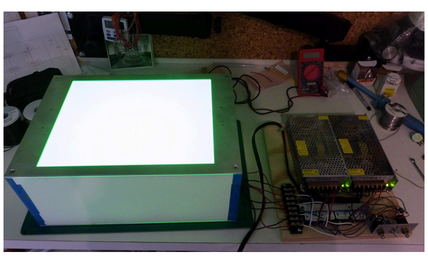
Testing for contrast range of the new LED

Earlier tests had shown that the green LEDs were absolutely not a problem, my main concern was centered around being able to achieve high contrast. My design goal was to, at a minimum, duplicate the highest contrast setting (pure blue only) of the Aristo neon VCL head. Initial testing using the prototype head showed a near perfect match to the neon. My worst fear of inadequate contrast was taken care of. The contrast range looked to be really good!

EVEN ILLUMINATION

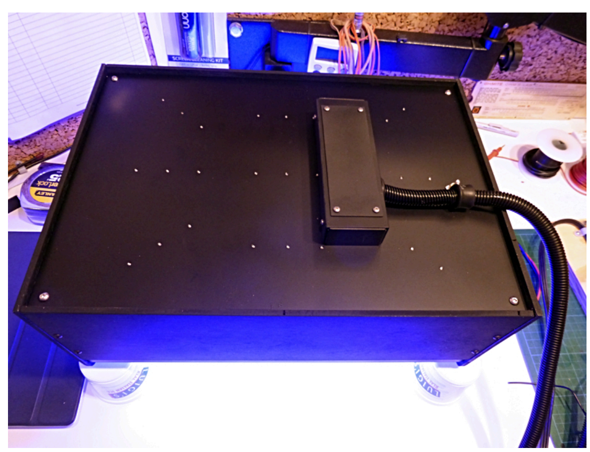
Another concern was making sure that the diffuser was evenly illuminated. Careful attention was paid to the beam width and placement of the LED assemblies. Several CAD drawings were made and the spacing and arrangement of the LEDs was worked out so that each LED has sufficient overlap of its beam to adequately cover the diffuser.

The original design utilizing 9 each of Blue and Green LED assemblies, carefully arranged on the back heat sink, proved to work as hoped. The LED assemblies were first attached with tape then wired to the power supplies and drivers. Both a Minolta Auto Meter IV F and a Pentax Digital Spot Meter were used to meticulously measure the edge-to-edge evenness of the illumination. The first arrangement of the LED assemblies yielded a mostly unmeasurable difference across the diffuser, so one design goal had been met. Holes were drilled and tapped in the back heat sink and the LED assemblies were attached using thermal paste and machine screws. There was also about a 1.5 stop increase in light output compared to the neon head!



Blue and Green at full power.

At this point everything was working as hoped. The 10-turn pots were trimmed to allow minimum turn-on brightness and a continuous increase to maximum light output of both colors. The prototype head was fitted to the enlarger and a second quick contrast range test was performed using VC paper. All worked as expected. Now it was time to build the final working head, the associated power supply and control box.

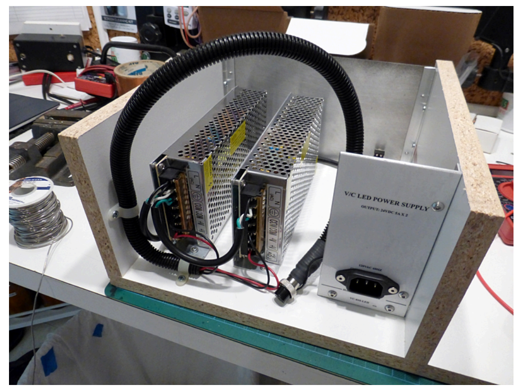


Finished LED Head with green and blue LEDs at full power.

BUILDING THE FINISHED LED HEAD

Back of control head.

The kluged up prototype controller needed to be formalized into a useable configuration. I really don't like to change things that work, so the decision was made to make it function exactly as the unit I built to control the old neon head. In fact, the box and layout of the controls were duplicated exactly as the old unit. Only the circuitry inside is different.



Power supplies and interconnect cable.

The prototype head was structurally finished, but only enclosed with some foam core for testing. I didn't want the new head to be any heavier than possible. The finished enclosure was made from very light 0.250" plywood, painted flat white inside and flat black outside. An aluminum bulkhead was machined to enclose the wiring umbilical on the top of the heatsink and to enclose the sensor for the Zone VI Compensating Enlarging Timer connector. Yes, we still use the compensating timer, though there should be no light drift, this way you know the exposure is repeated. Besides, we like the timer and how it works.

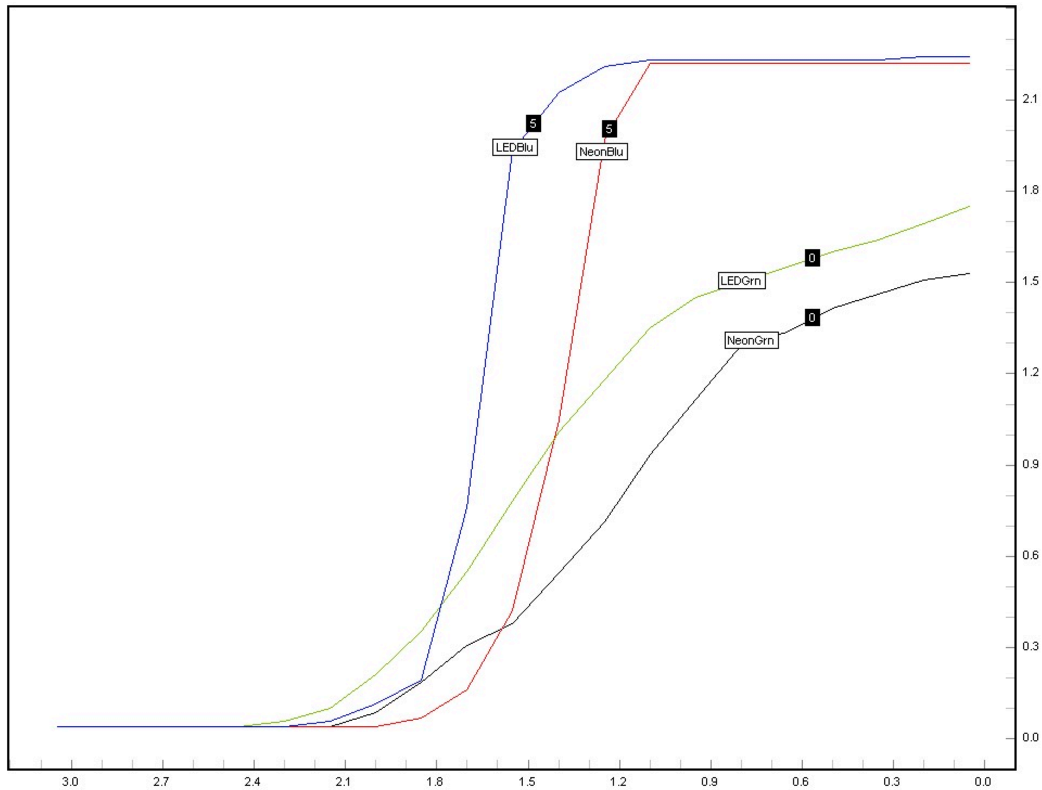
Control head wired and ready for testing.

A new Melamine box was constructed to enclose the power supplies, to hold the timer and the new LED control box at the top. This is exactly like the old neon control box and timer arrangement used with the original neon controller. The function of the control box is the same as the original neon unit.

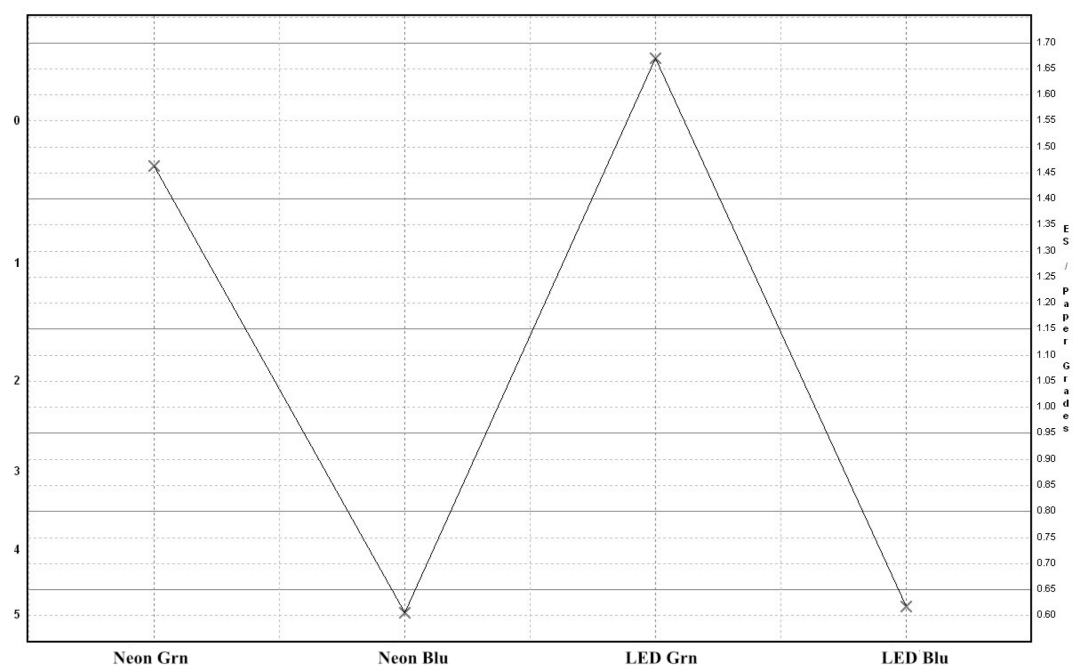
THE FINAL TEST

No project is done until it is proven to work. With this one, the only way to know is to put it to use. We have now both used the new head and we have found it to work as hoped. We are both 100% confident that we have a solid working LED VC Head. The only other thing that had to be done was some mechanical upgrades to the 8x10 enlarger. The 8x10 enlarger was built some time ago as a proof of concept and feasibility study. It worked so well it has become the workhorse of the darkroom. Thing was it needed some structural improvements and some machine work to make it easier to align. That was another project but all is done now. The enlarger is up and working!

All is now good!



LED vs Neon plots of low contrast (green) and high contrast (blue) maximum.



LED and Neon contrast range.

WHAT LEDs AND STUFF

I know that someone will want to know exactly what LEDs and associated parts were used for this project. Here is what was used and the sources. Keep in mind that technology is a moving target. . . what is cutting-edge today is trash tomorrow. . . think about that D-WhatEver camera you bought two yeas ago!

LED:
Cree XLamp XT-E Royal-Blue LED LEDsupply Part#: CREEXTE-ROY-X

Cree XLamp XP-E2 Green LED LEDsupply Part#: CREESPE2-GRN-1

LED Driver:
LUXdrive A009-D-V-1000 A009 BuckBlock LED Power Module LEDsupply Part #: 0A009-D-V-1000

DC Power Supply:
24v 5A Open Frame Switching Power Supply (readily available on eBay and other sources)

SUPPLIERS:

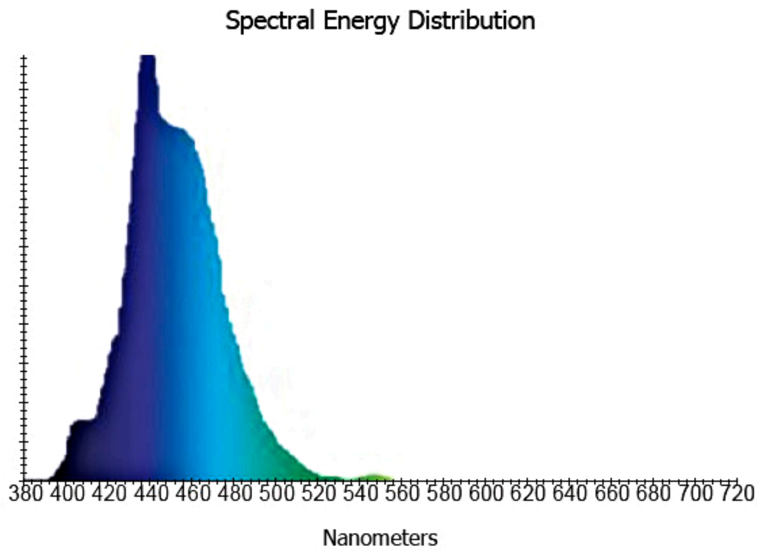
LEDsupply http://www.ledsupply.com

Digi-Key http://www.digikey.com

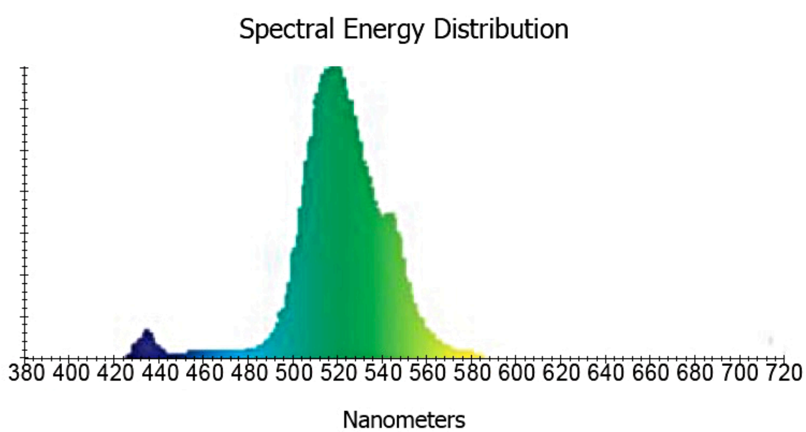
Mouser Electronics http://www.mouser.com

Also try eBay and an Internet Search

NEON SPECTRUM



Cobalt Blue Neon spectral output.



Emerald Green Neon spectral output.