Mod Cookbook - the OA4D

First, a little legalese. All mods are to be done **at your own risk,** for better or for worse. This mod is NOT endorsed by Mag Instrument and WILL assuredly void your warranty. You are responsible for any good and any bad which arises from this mod, and we are not responsible for the use or misuse of the information represented herein. All trademarks are recognized as property of their owners and are only used for identification purposes. While reasonable effort has been made to ensure the accuracy of this webpage, I will not be responsible for typographical, technical or other errors contained within.

Alternative recipes can be found here. These include using an OA3C/OA3D instead of a 4-cell platform, and a regulated 5W conversion.

With that out of the way, the OA4D modification is, IMHO, one of the most popular and yet simple mods on CPF. Due to the popularity of the basic aluminium flashlight platform on which this is based, most of us are likely to have one sitting around. For just a little investment of time and money, and minimal tools, you can turn the light into something that you can be proud of. It's been said before that it's impossible to put a price tag on mods because of the intrinsic rewards, and I can agree. This page aims to present as much info and background as possible for the novice modder. I'm assuming that you have no background in modding. I also seek to explain some of the CPF terms here in order to demystify the lingo.

This mod aims to retrofit an OA4D aluminium light with a Luxeon LED light source. OA4D is a CPF term for a popular kind of flashlight, as shown in the pics below. The last two characters refers to the number of cells the housing can accept. So a 4D would be 4 D cell batteries. A 3C would be 3 C cell batteries. References to "OAC" or "OAD" refer to all C-sized lights and D-sized lights respectively, regardless of battery configurations. The reason why the Luxeon Light Emitting Diode (LED) is popular is because it is phenomenally bright, virtually shockproof (based on solid state semiconductor technologies with no bulb to break) and when cared for properly, has a life expectancy of tens of thousands of hours. Unlike previous LEDs you may have encountered in indicator lights (look at your computer keyboard, there are three of them), Luxeons are orders of magnitude more powerful - they deliver enough light to be used as portable lighting sources.

LEDs are not bulbs, however. You cannot simply drop one into the housing and expect to go, at least, not in their raw form. Some manufacturers build LEDs into a PR base (the type of housing the stock bulb uses) so that you can literally replace a bulb with a LED. However, for this mod, we will be using the most basic building block of Luxeon LEDs - the emitter. The size of a tic-tac, the emitter is the heart of the LED, and that's all there is to it. It's got two contacts, you solder your wires onto it and you're good to go.

Well, not really. LEDs are not bulbs and they behave differently. With a bulb, all you need is enough voltage from your battery pack to get it to light up. Too little voltage, it glows dim. Too much, and the bulb won't last very long. With LEDs, a little bit more electrical engineering background is required. They have a specific forward voltage, termed Vf. Your power source MUST be able to supply more voltage than the LED's Vf, or you will get no light at all. Despite that, LEDs are not voltage based devices. They are CURRENT based devices.

In this mod, we will be using a Luxeon 3, with approximate Vf of 3.9 volts, and a 6 volt (nominal) power source of 4 x D cell batteries. If we were to simply wire everything up in a traditional circuit (batteries, switch, and bulb/LED), this circuit would be capable of pushing huge amounts of current through the LED. Luxeon 3's are speced at 1000mA (or 1 amp) maximum. Exceeding this maximum is done at the modder's own peril. Many have done it, but it is not something to be undertaken without understanding the true nature of the LED. This is called Direct Drive by many, where a LED is literally driven directly off the batteries. It's also known as "living dangerously" by others.

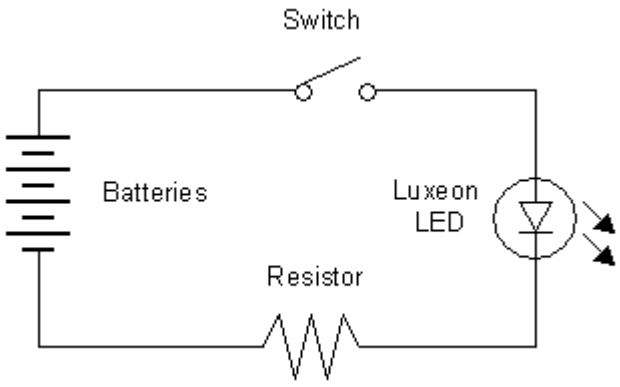
We need some way to limit the current supplied to the LED, in the form of a resistor. Those of you familiar with Ohm's Law may recall the specifics, 6 volts - 3.9 volts = 2.1 volts. To obtain a 1 amp current, we need to divide 2.1 by 1 amp, which gives us a 2.1 ohm resistor. Inserting this resistor in series with the LED will restrict current to 1 amp. Your resistor MUST be able to handle the current that itself has to dissipate, and in this case, it comes out to about 2.3W minimum. You are advised to buy a 3W resistor. DO NOT get a 2W resistor.

For those of you who do a lot of calculations, or are looking for an easier way to get the job done, you can use the excellent LED Pro resistor calculator published by jtice from CPF.

I myself am shown using a 1 ohm resistor here, but this is after a lot of measuring with actual hardware and a DMM to determine whether the current will stay within LumiLEDs' 1 amp spec for the Lux3. The above "theoretical" calculations are very much on the safe side. If you want to make the light brighter, you can use lower resistor values, again **USE PROPER CAUTION.** 1.5 ohms is a reasonably safe value. If you do exceed the max spec current you can seriously shorten LED lifespan or even blow the LED. I take no responsibility if you decide to adjust resistor values and destroy the LED in the process!

(Extra technical info: Realistically, batteries, housings and switches have their own resistance as well. The Luxeon will be driven at less than 1 amp in this configuration using a 2.1 ohm resistor. If you have a multimeter, you can use it to figure out the resistances, and adjust the resistor value appropriately. Values given here err on the SAFE side of things - I'm playing it safe. Still, it is your responsibility to doublecheck everything, and investing in a digital multimeter (DMM) is certainly very worthwhile.)

So in the end, your basic circuit will look like this - batteries, switch, resistor, LED. From here on, you can either graduate to direct drive, or more sophisticated constant-current regulated circuits. But I won't go into so much detail.



Luxeon LEDs also put out copious amounts of heat, unlike their lower-powered brethren, and this heat buildup has to be managed, if not you will cook the LED very quickly. If you have not yet assembled everything, DO refrain from the temptation of powering up the LED without a suitable heatsink. You will also need some way of mounting the Luxeon in the OA4D housing as the conventional PR bulb housing will not do. Fortunately, a solution to this problem comes together - a gigantic block of precision machined aluminium that also serves as a mountpoint for the LED and a heatsink.

It's called the Hotlips and can be ordered direct from its creator, Hotbeam, as well as purchased from the Sandwich Shoppe. Please read the information in the Hotlips link in addition to this cookbook - much of it is very useful. You can either order the Hotlips bare, or with a Luxeon already affixed to it using a thermally-conductive epoxy (Arctic Alumina epoxy, also known as AA.). If you choose to buy your Hotlips and emitter separately, DO NOT use normal epoxy to glue the emitter to the mounting pedestal in the center of the Hotlips! You must use something that is thermally conductive, as normal epoxy does not conduct heat very well, defeating the objective of the heatsink and cooking your expensive LED. The Shoppe has AA available if you can't find it locally (try your computer shop, AA was originally developed for the geek community and their ever-overheating components).

You may want to note that older OADs without a "D" in the serial number may not be able to accept the Hotlips due to differences in internal diameter. According to the link above, the D sized sinks are ~34mm, and the C-sized sinks fit newer OACs with a C in the serial number at 26.3mm. There is a conversion sleeve available for older OAC owners, please check with Hotbeam. Unfortunately, older OAD owners may be out of luck.

Thus far, your parts checklist will read like this :

- OA4D aluminium flashlight (new version)
- Hotlips heatsink (purchase from http://hotlips.hotbeam.com)
- Luxeon 3W emitter (from hotbeam.com as above, or try the Sandwich Shoppe)
- 52.1mm Ultra Clear Lens (UCL) or Borofloat lens from www.flashlightlens.com. See explanation on the next page.
- Batteries for the light
- 2.1 ohm, 3 watt resistor
- 2mm or 5/64" Allen key

Hotbeam and the Shoppe ship internationally at very reasonable rates, so you need not worry about missing out.

In addition to all these, baseline proficiency with a soldering iron is a must. I'm assuming you already know the essential tools required for soldering. A small 25W sharp tip iron will be adequate. The Allen key is required to open the guts of the OA4D. I haven't mentioned it yet, but it is a must-have.

Got all your stuff? Proceed to the actual operation itself.. >>

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Have you read part 1 yet? There is some very important info there.

Now begins the actual operation. First, you have to strip the OA4D. Pinch the rubber boot covering the switch, it should come off fairly easily. The switch will be exposed. Unload the batteries, unscrew the head, and leave them aside. Insert the allen key into the center of the switch as shown below, until it reaches the set screw inside. If you turn it, you'll be able to feel when it 'catches' or engages the screw. It may take some force to loosen the set screw, work carefully.

Once the set screw comes loose, the housing should simply drop out of the bottom of the tubular housing. You may need to apply a little bit of pressure on the bulb end to get it to come out.

Find the copper-colored knob on the side of the bulb post of the switch assembly, stick the allen key in and unscrew the little knob. Make sure the spring-loaded bulb post does not fly out...unless you don't plan on seeing it again.

(actually, you won't NEED to see it again if all goes well, but.. never mind.)

On the base of the switch assembly, there is a blue component, with a hex screw in the middle and an aluminium strip. Using a screwdriver as shown, gently pry it up and remove it.

Now, saw the bulb post off. A hacksaw or a file should do it. Other unorthodox methods have been tried and can be used in a pinch, at your own risk, as always. Do not cut all the way down, you can safely leave 3-5mm as shown here :

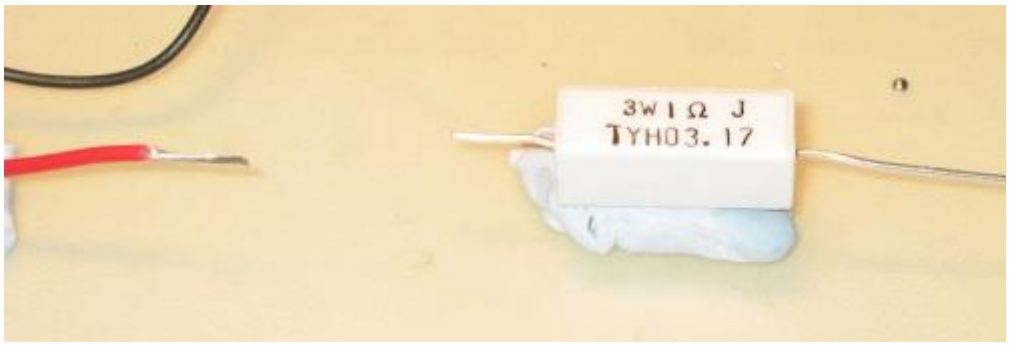
Put the metal strip back in and trim it to a shorter length so that it is flush with the top of the (now shortened) bulb post. The strip extends all the way to the top of the bulb post, now that you've cut the post down, cut the strip down to match. The strip is on the right, lying on its side. It is much wider than shown in the photo.

You can now solder a length of wire to it. 22-24AWG wire works well. Stranded wire needs to be tinned, and will provide more flexibility to work with. You can also use 24AWG solid core wire, if you have access to Category 5 computer network cable, the 8 wires inside are almost certain to be 24AWG. Solid core wire provides less bendability,

but for this mod, where we will install the wires once and leave them to sit, it is acceptable. When soldering, remember, the CENTER contact is positive, and the long strip you just put back in is NEGATIVE. If you mix up the polarity, your LED will not light! The black wire is just touching the top of the metal strip.

Slot the switch assembly back into the housing and use the allen key to tighten the set screw to 'fix' it back where it should be. Replace the rubber boot.

Solder the resistor to one of the wires. Any wire will do, here it's shown being soldered to the red wire (positive). You'll need to solder another wire to the other end of the resistor (of course). If you want to use the same resistor I'm using in the pic, please read my warning in part 1 about destroying LEDs with too much current.



Blue Tack is your friend when soldering, mmmk? It prevents things from running around. Use your imagination, but believe me, it makes it MUCH easier to work hands free. There are more sophisticated soldering stands and holders, but in a pinch, it works surprisingly well.

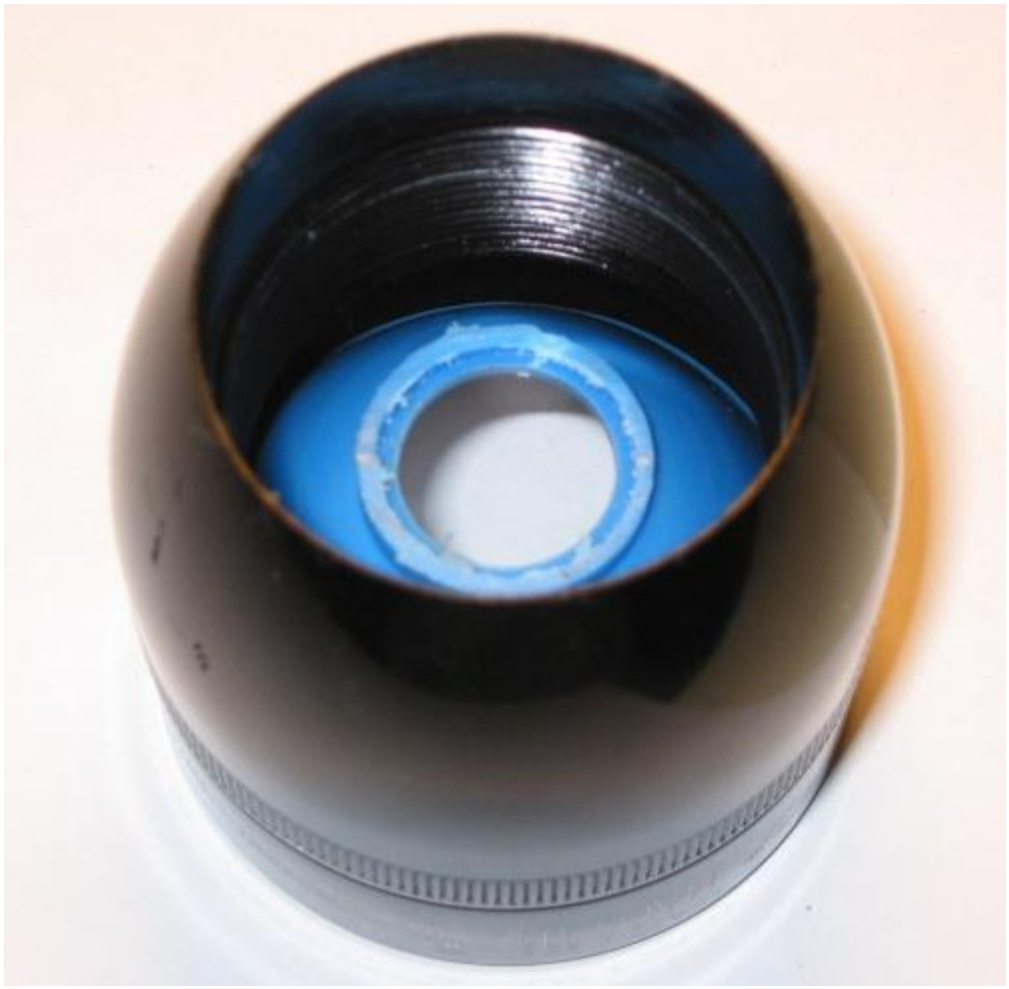
My Lux3 (a TWOL bin, for those of you who know what it is. If you don't, it won't affect your chances of successfully completing this mod, don't worry) was already AA'ed to the Hotlips pedestal by the master himself, so I just threaded the wires through the holes (here's where 22AWG will make your life easier) and soldered them to the contacts of the Luxeon. A word of advice: there are small stubs sticking out next to the LED contacts. DO NOT short your wires against those. The side with a O in the little stub is POSITIVE. The other side with a notch is NEGATIVE. Do not mix

up your polarity. Test before you solder. I've messed it up before on another mod I did. If in doubt, check the LumiLEDs Luxeon 3 Datasheet. They should be considered authoritative on this subject.

You will need to mount the Lux yourself if you order the emitter and Hotlips separately. I ordered a prepackaged combo because he had one of the elusive T-bins and a very good bin at that. Simply dab a thin as possible layer of AA onto the pedestal and smack your emitter onto it. Leave and let cure, then thread your wires through.

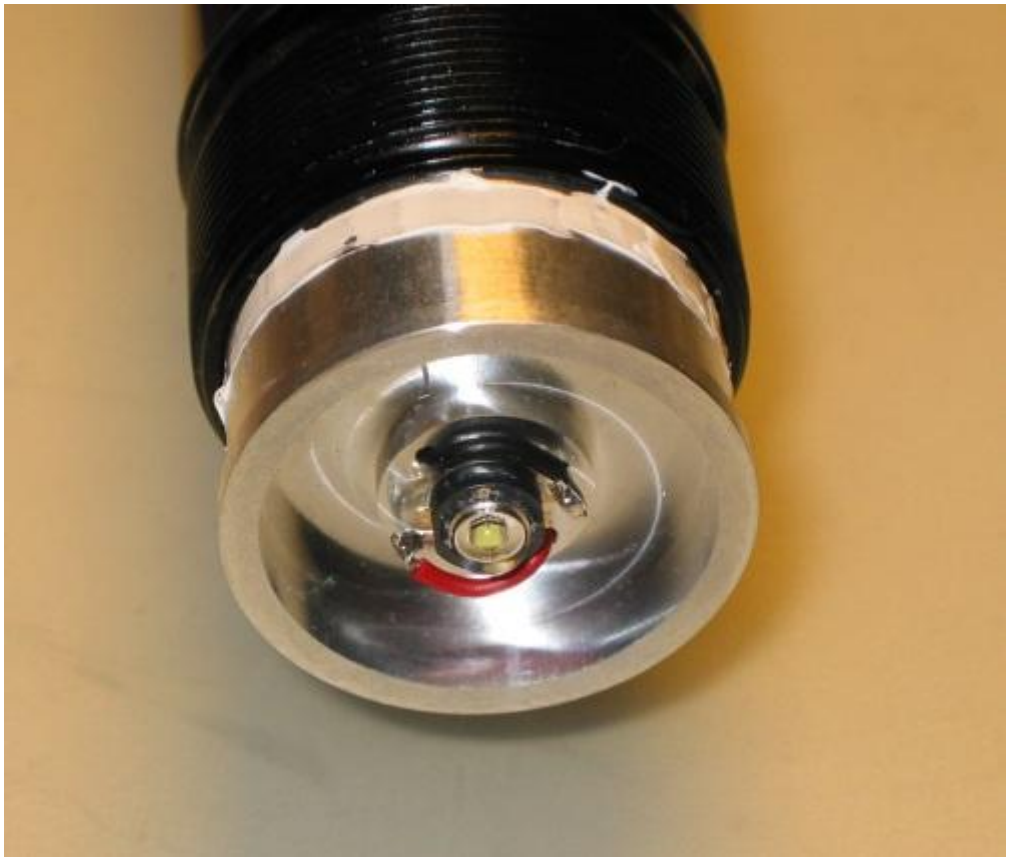
Note that the side with the "O" designates [CHECK AND CONFIRM from datasheets]. Connecting the Lux in reverse will result in nothing lighting up - a diode needs its polarity to be correct. Been there done it on another one of my mods.. sheesh.

You will also need to saw the reflector's cam down. Unscrew the very top part of the reflector housing, and the reflector pops out. DO NOT WIPE THE REFLECTOR SURFACE - no matter how soft your cloth you will cause damage. Try not to damage it while sawing. You'll need to cut it down so it will fit. Leave around 1-2mm of the 'tail'. You will still be able to focus after you are done, though not as much as the original flashlight.



Now, fit the Hotlips into the center of the aluminium housing, pushing the resistor and the wires in. According to Hotbeam you may need to sand the interior of the aluminium housing if the Hotlips does not fit. Mine fits perfectly, provided I align it properly. You must be dead level with the tube, before it slips in with some gentle pressure.

Before slotting mine all the way in, I spread some thermally conductive grease (available from any computer shop) onto the bottom of the Hotlips. I used a flatblade screwdriver to help me apply an even, small ring. The reason why I do not coat the entire heatsink with it is that when I push it down, the excess grease will be spread evenly across the surface of the heatsink all the way to the top. You may have to wipe off a little bit of excess if it comes out of the top. This step is optional if you don't have the grease, but I happen to have quite a LOT of it (one of the evils of dealing with computers on a day to day basis). Use sparingly, the less the better.



Once done, reassemble the entire light. Hit the switch. Take photos of how pretty it is. Report back to CPF on your success or failure. Blind yourself by looking into the light (we all do it from time to time, whether on purpose or accidentally). Try it in candle mode without the reflector. Walk around the whole night with it on just so you can enjoy it. Good luck with your mod.

For that extra special touch, you can replace the easily scratched polycarbonate lens with a 52.1mm Ultra Clear Lens (UCL) from Flashlightlens.com. As an added bonus, you'll get scratch resistance, antireflective and antiglare coatings (AR/AG), and improved light transmission so you'll get even more from the Luxeon than before. They don't call it the Ultra Clear for nothing - after I've replaced my stock lens with it, it looks like there's no lens at all. Very highly recommended.

Special thanks to : Hotbeam/Rothrandir for making the Hotlips available to the modding community at a very reasonable price, and all others on CPF whose postings have influenced this mod, directly or indirectly, and without whom this mod would have not been possible.

Additional References

- LED Pro resistor calculator
- Hotlips 'D' from Hotbeam
- Ya ready for this? -- 13,200 Lux from an LxIII !!
- Mag 4D LuxIII Mod w/Pics
- First Flashlight Mod, M@G
- A simple Mag mod I did today

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