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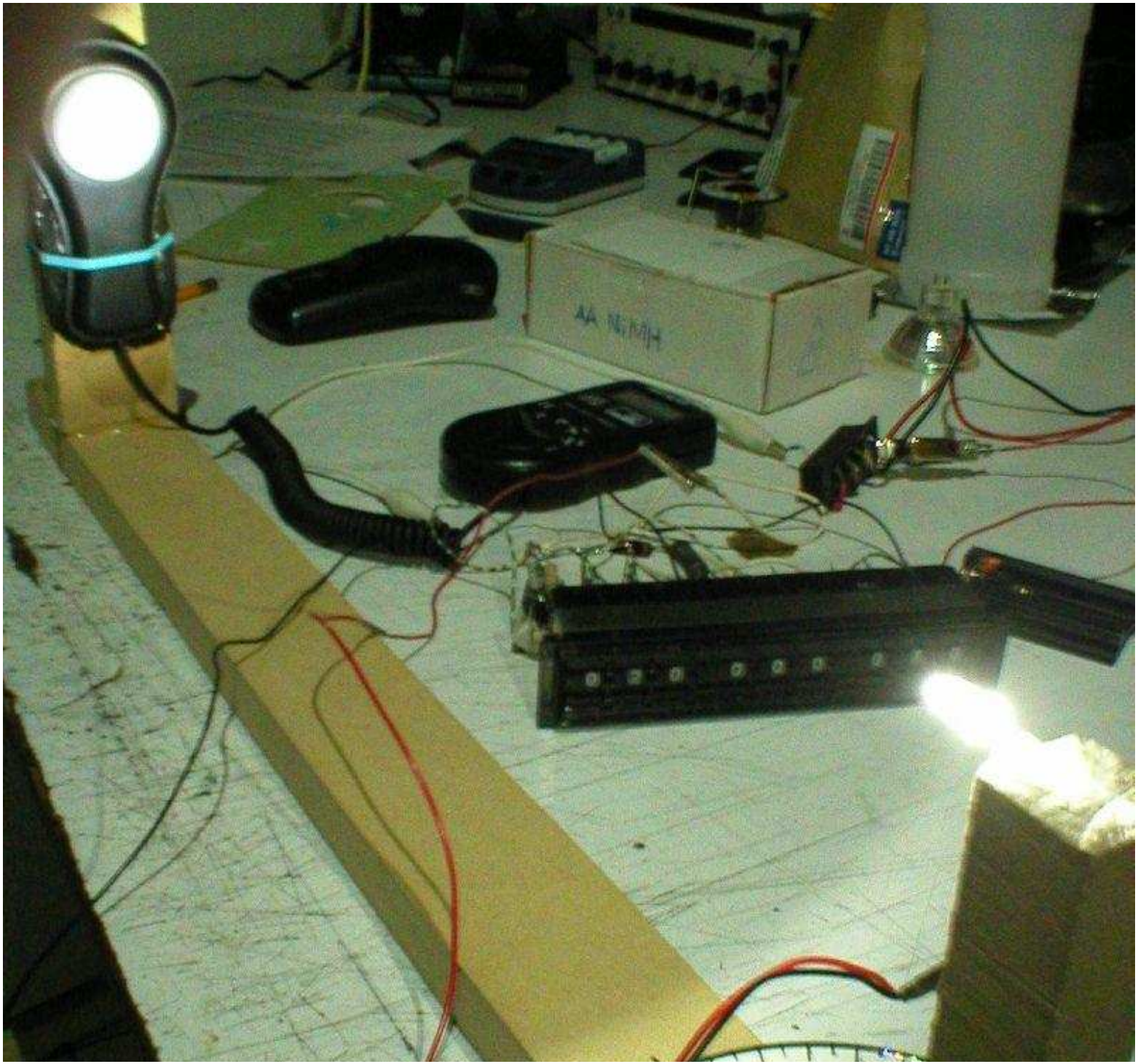
White LED lumen testing

Having acquired quite a few different types of white LEDs over the last two years I've long wanted to see how they stacked up against each other. To that end, and since summer is traditionally my season for indoor projects, I ran a slew of tests. Besides the usual intensity and Vf measurements, I also built a device to enable me to estimate lumen output:



I made a cradle to hold my light meter out of silicon rubber for consistency of measurements. An old CD serves as the dial to rotate the LED. Starting at 0°, I first position the LED so that the light meter reading is as high as I can get it in order to obtain a hot spot reading. This is important because the relative value of all the other measurements to the highest reading is what will ultimately determine the accuracy. I record the reading, and then rotate the dial in 5° increments all the way to 180°, recording all the light meter readings. A few times during the test I block off the LED in order to obtain a background reading which needs to be subtracted from all the readings. The value is usually 0.1 to 0.2 lux, and while it may not sound like much, at the 17.5" distance between the LED and light meter it can affect the final result by as much as half a lumen.

After I obtain my results on the test jig running the LED at 20 mA I then take lux readings of the LED at one meter at different currents using the constant current source with the thumbwheel switches to change the current. I also record the LED's Vf. I then plug all the data into an Excel spreadsheet made for that particular LED and come up with the final results. Here is a .zip file containing all my spreadsheets so far for anyone who wants to see how I do my calculations.

Before showing graphs of the results here is a list and short description of the LEDs I tested so far in order of date of purchase (all are from eBay with the exception of the Hebei LED and the old Nichia):

Nichia(?) 5600 mcd, 20° 5mm white (purchased 2001 from Hosfelt Electronics)
A bought a pair of these for $3 each back in 2001 when white LEDs were something of a novelty. In fact, until I started buying on eBay I only had a handful of white and blue LEDs as they were just too pricey to buy in quantity. Anyway, based on the tapered shape and the warm color this LED is probably a Nichia. It actually greatly outperformed the 5600 mcd spec, and did surprising well for a 4-year old white LED, coming in at 28 lm/W efficiency at 20 mA. The tapered shape seems to avoid the ring of light at 60° off-axis as is the case with straight narrow viewing angle 5mm LEDs. As a result, the hot spot is brighter for a given lumen output, and very little light comes out the back.

SpectrumLEDs (noshankyhank at time of purchase) 6,000 mcd, 30° 5mm white (purchased May 2003)
The first white LED I purchased on eBay. Very blue tint.

ChiWing 5,000 mcd 3mm white (purchased July 2003)
Bluish color, wide angle beam.

ChiWing 8,000 mcd 20° 5mm white (purchased July 2003)
Slightly bluish-green, outperformed specs, fairly long-lived based on the one used in my PC as a power indicator. Very low Vf in the 3.00 volt area.

BestHongKong 10,000 mcd 20° 5mm white (purchased February 2004)
Slightly purple, outperformed specs, degrades almost instantly at drive currents above 60 mA.

SpectrumLEDs 8,000 mcd 20° 5 mm white (purchased November 2004)
Decent color but very dim for a late 2004 LED, seemed to degrade rapidly even at 20 mA.

warden_jp2002 26,000 mcd 20° white (purchased February 2005)
Slightly bluish tint, the highest output LED tested by me to date due to a slight wider beam for a 20° LED, no longer available on eBay.

Hebei L5B47VW5C 60° 5mm white (purchased March 2005)
Nice color, wide angle beam, purchased for testing for use in my taxi lighting project. Ultimately rejected for that purpose due to costs and output but still a quality LED, and probably very-long lived.

LCK 12,000 mcd 20° 5 mm white (purchased July 2005)
White with just a hint of blue, greatly outperformed specs, maybe these are LCK's 26,000 mcd LEDs which were put into a 12,000 mcd bag by accident.

BestHongKong 25,000 mcd 20° 5mm UWLC series white (purchased July 2005)
The UWLC series is designed for better color rendering and purer white. These LEDs excel on both counts, especially when rendering reds, and are neither too blue nor too yellow, coming in at a color temp of around 5000K. A slightly wider beam than most 20° LEDs, these come in near the low end of their 14,000 to 25,000 mcd range spec, average in the 16,000 to 17,000 mcd range. The wider beam gives them more output than would be expected for an LED with their intensity.

Light of Victory 35,000 mcd 20° 5mm white (purchased July 2005)
The second best color of any LED I've tested so far. Intensity is a close match to the warden_jp2002 26,000 mcd whites but slightly less in lumen output. These seem a match for the Nichia CS in terms of both lumens and intensity. Low Vf compared to most other white LEDs.

LCK 12,000 mcd 20° 5mm warm white (purchased July 2005)
The first warm white LED I've purchased. Color temp looks like 3200K to 3300K. As with the LCK 12,000 mcd white, it outperformed specs.

Jeled 40,000 mcd 20° 5mm white (purchased December 2005)
Very similar color to the Light of Victory 35,000 mcd, and identical lead frame design. Intensity is nearly 31,000 mcd at 20 mA, a new record for 5mm, 20° white LEDs. Vf is middle of the pack at 3.3V at 20 mA. I also managed to reach over 70,000 mcd at 80 mA, well above my previous records. These intensity records seem to be mostly because the beam is a bit more tightly focused rather than from increased output. Efficiency at 20 mA is a solid 70 lm/W, still less than the warden_jp2002 from early 2005.

BestHongKong 40,000 mcd 20° 5mm white (purchased January 2006)
Note that these are NOT the UWLC series pure white but are optimized for intensity instead. Part number is BEB1000003-100. They are slightly bluish white rather than pure white, maybe about 8000K, but with a very even beam. They are also not anywhere near 40,000 mcd at 20 mA due to a much wider than usual beam. A few of the ones with tighter beams were in the 25,000 mcd area but most were about 20,000 mcd. Vf is a bit on the high side at 3.4V to 3.45V at 20 mA. Thanks to the wide beam, output and efficiency are close to the best I've measured so far. In fact, at 5 mA these set a new efficiency record of nearly 97 lm/W. Although I didn't test at lower currents, they may well break 100 lm/W at 2 or 3 mA. Given the results of this test and the Jeled 40,000 mcd, there hasn't been that much improvement in overall white LED efficiency since early last year,

although LEDs of top efficiency are now more widely available (remember that the record setting warden_jp2002 26,000 mcd LEDs last year were a very limited run, and it took until late in the year before comparable LEDs were widely available).

Jeled 50,000 mcd 20° 5mm white (purchased January 2006)
Identical to their 40,000 mcd LED in design, except the color is slightly whiter. I tested three samples and averaged the results. In short, I broke all my previous records by a good margin. Intensity averages around 41,000 mcd at 20 mA and 55,000 mcd at 30 mA. I also reached average intensities over 90,000 mcd at 80 mA. One of the three with a somewhat tighter beam managed over 100,000 mcd at 80 mA. Vf is tending to the high side at 3.4V at 20 mA. Efficiency at 20 mA averaged 82 lm/W, well above previous records. At 5 mA all three samples were well above 100 lm/W, with an average of 110 lm/W. Just for kicks I tested at lower currents to see if efficiency improved further. It did, averaging nearly 125 lm/W at 1 mA, which is well into HID and HPS territory. Assuming a luminous efficacy of 330 lm/W, typical for white LEDs, energy to light conversion efficiency at 1 mA is around 40%. I also noticed an interesting phenomenom. After I test intensity versus current, I measure the intensity and Vf again at 20 mA just to see if the LED's characteristics changed from the excursion to 80 mA. Usually I find little if any change, and it's usually just a slight decrease in intensity from being abused. In this case, I not only found that intensity was *higher* after the test, but also that Vf was lower! This is very much what happens with a Luxeon. Because of this I redid the entire intensity versus current tests for all three LEDs after the initial "burn-in", for lack of a better word. Overall the changes bumped the average efficiency from about 75 lm/W at 20 mA to the 82 lm/W figure mentioned earlier. The changes also occurred in an LED that was run at 20 mA overnight.

Peak Snow 29 5mm white (acquired February 2006)
CPF member **Pinter** was kind enough to send me 5 samples of the Peak Snow 29 LEDs for testing. These LEDs have a wider than usual beam and a very even color. Color temperature on one sample looked like about 5500K with the rest falling around 6500K. Efficiency on these was impressive, averaging nearly 80 lm/W at 20 mA for the 5 samples. Even more interesting was that the samples ranged from 70 lm/W all the way up to a bit over 90 lm/W at the nominal 20 mA. Average intensity was 21,260 mcd and average output was 5.11 lumens, both figures about equal to the Nichia CS. This verifies the claim Peak makes which states that the Snow 29 LEDs match the Nichia.

Nichia CS bin B1U 15° 5mm white (acquired February 2006)
Along with the Peak Snow 29 LEDs Pinter also sent me 4 samples of the Nichia CS LEDs. At the nominal 20 mA operating current these came in at close to 75 lm/W, 4.83 lumens output, and 24,100 mcd intensity. The consistency between samples was very impressive as well-the worst measured 70.6 lm/W while the best was 76.0 lm/w, a variation of less than 8%. Where the Nichias really shined (pun intended) was at higher currents. The majority of LEDs I've tested increased little in output beyond about 70 or 80 mA, and so I usually stopped the testing at 80 mA. The 80 mA output was typically about 2.2 to 2.5 times the 20 mA output. On the other hand, the Nichias gave about 2.75 times their 20 mA output at 80 mA, and the curve showed no signs of flattening out. Therefore, I tested up to 100 mA, which is as high as my test jig goes (and the absolute maximum limit for 5mm LEDs). At 100 mA the Nichias were giving nearly 3.1 times the 20 mA output, or on average nearly 15 lumens! To put this into perspective remember that this isn't much less than Luxeons were giving a few years ago, and at 350 mA. Furthermore, the Nichias showed no signs of stress following their brief excursion to 100 mA. Their output at 20 mA once they cooled down was exactly the same as before. If you really need to overdrive a 5mm LED, then the Nichia is the best candidate.

MPJA 15,000 mcd 10mm white (acquired July 2006)

This is one of four different types of LEDs sent to me by CPF member **milkyspit** for testing. I wasn't expecting much based on the 15,000 mcd rating since this is way under the ratings for similar very narrow beam 10mm LEDs from other manufacturers. The five samples all exceeded their ratings by a large margin, coming in at 41.4, 47.8, 60.0, 62.9, and 81.9 cd at 20 mA. I tested the lumens on the best and worst ones, and averaged the results. Of course the intensity far exceeds anything I've tested to date, but this was expected given the tight focus. The efficiency averages a respectable 60.9 lm/W at 20 mA. Color is somewhat blue, with a color temperature of roughly 9000K. The beam is as smooth as can be expected from an LED with as tight a focus as these, but the bond wires and die are clearly visible. Measured beam angle is only about 8.5° but alot of light falls outside the main beam.

unknown 26,000 mcd 5mm white (acquired July 2006)
This is the second of four different types of LEDs sent to me by CPF member milkyspit for testing. After testing I'm reasonably sure that this *isn't* one of the warden_jp2002 26K LEDs which milkyspit thought it might be. Rather, the tapered shape causes me to think this is a Nichia. Based on the color and intensity, I'd say it's a Nichia CS 1BU rank T, and this is what I labeled the results as. The three samples came in at 15.5, 16.8, and 17.9 cd at 20 mA. I tested the middle one for lumens. Efficiency is 61.6 lm/W at 20 mA. Unlike the othe Nichia CS LEDs I tested, these don't do as well at higher currents. The output is more or less maxed out at 80 mA. These may in fact *not* be Nichias, but if so I have no idea what they are.

LS Diodes THC3 4-die 5mm white (acquired July 2006)
This is the third of four different types of LEDs sent to me by CPF member milkyspit for testing. This is the first quad-die LED I've ever tested so the results are quite interesting. The beam is very smooth and white, coming in at about 6000K. Half-intensity beam angle is fairly wide at 27.4° so the intensity is nothing to write home about, reaching only 8,300 mcd at 20 mA. Efficiency at 20 mA is 72.8 lm/W which is very respectable. Note though that since each die is only receiving 5 mA this number isn't as good as it appears at first glance. Where this LED shines is at higher currents. Once you exceed 40 mA it surpasses every 5mm white LED tested to date in efficiency. Even at 100 mA efficiency is still a very decent 50.1 lm/W. As expected, forward voltage is very low compared to other 5mm whites since each die is only getting 1/4 of the current.

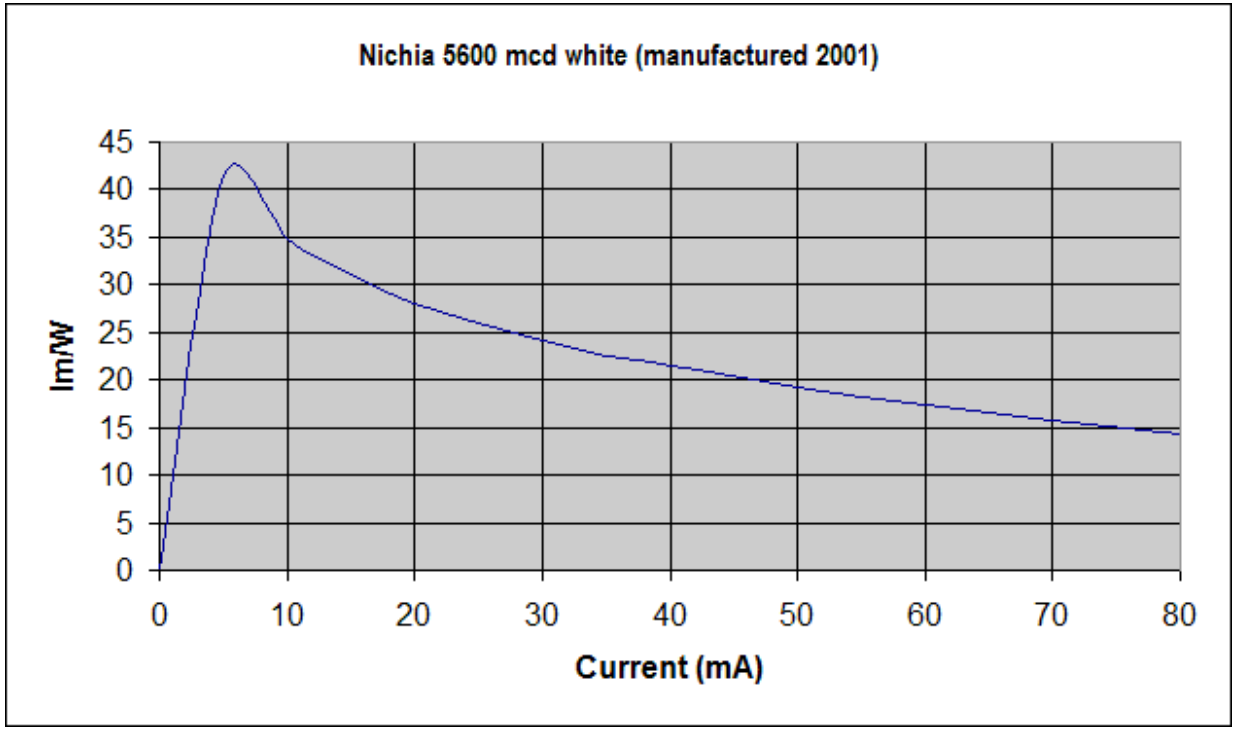
SMJLED 4-die 5mm white (acquired July 2006)
This is the fourth of four different types of LEDs sent to me by CPF member milkyspit for testing. As with the LS Diodes THC3, the beam is very smooth and white. Color temperature is about 6500K to 7000K. Beam angle is fairly wide (31.6°) so the intensity is low, reaching only 7,100 mcd at 20 mA. Efficiency at 20 mA is 87.8 lm/W which is a new record. Once again, note that since each die is only receiving 5 mA this number isn't as good as it appears at first glance. Again, this LED shines at higher currents. Once past 20 mA it surpasses every 5mm white LED tested to date in efficiency. At 100 mA efficiency is 57.2 lm/W. As expected, forward voltage is very low compared to other 5mm whites since each die is only getting 1/4 of the current. Lumen output far exceeds any 5mm LED tested to date, reaching 17.67 lumens at 100 mA. While these numbers are great, remember that at 100 mA each die is only getting 25 mA. Just for comparison purposes four Jeled 50,000 mcd whites each running at 25 mA would output 26.5 lumens at an efficiency of 76.7 lm/W. Basically, this means that the dies used in the SMJLED (and the LS Diodes THC3) are decent, but not the best available.

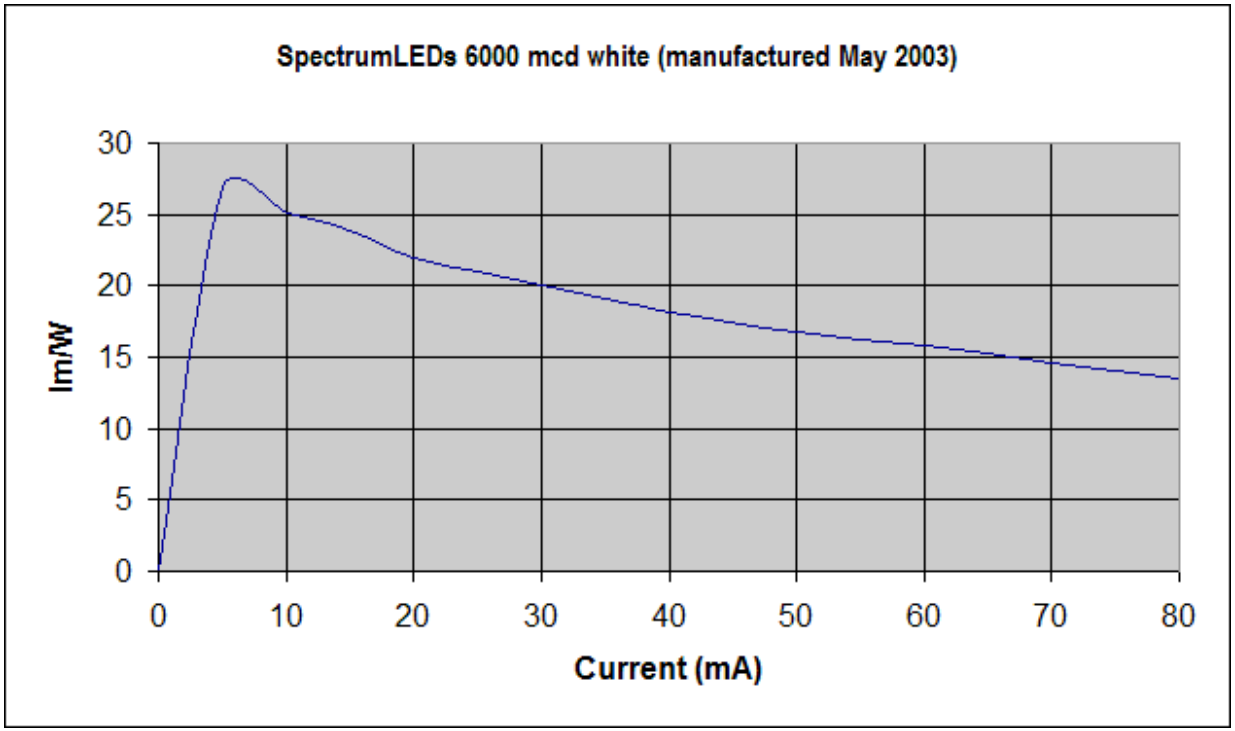
Nichia NSPW310BS-E 60° 3mm white (acquired August 2006) ***NEW!***
I purchased 200 of these on eBay to be used for lighting projects requiring very small LEDs. The beam is bluer in the middle, and most of the LEDs seem to have a color temperature in the 6500K to 7500K range. A few are significantly more blue or yellow

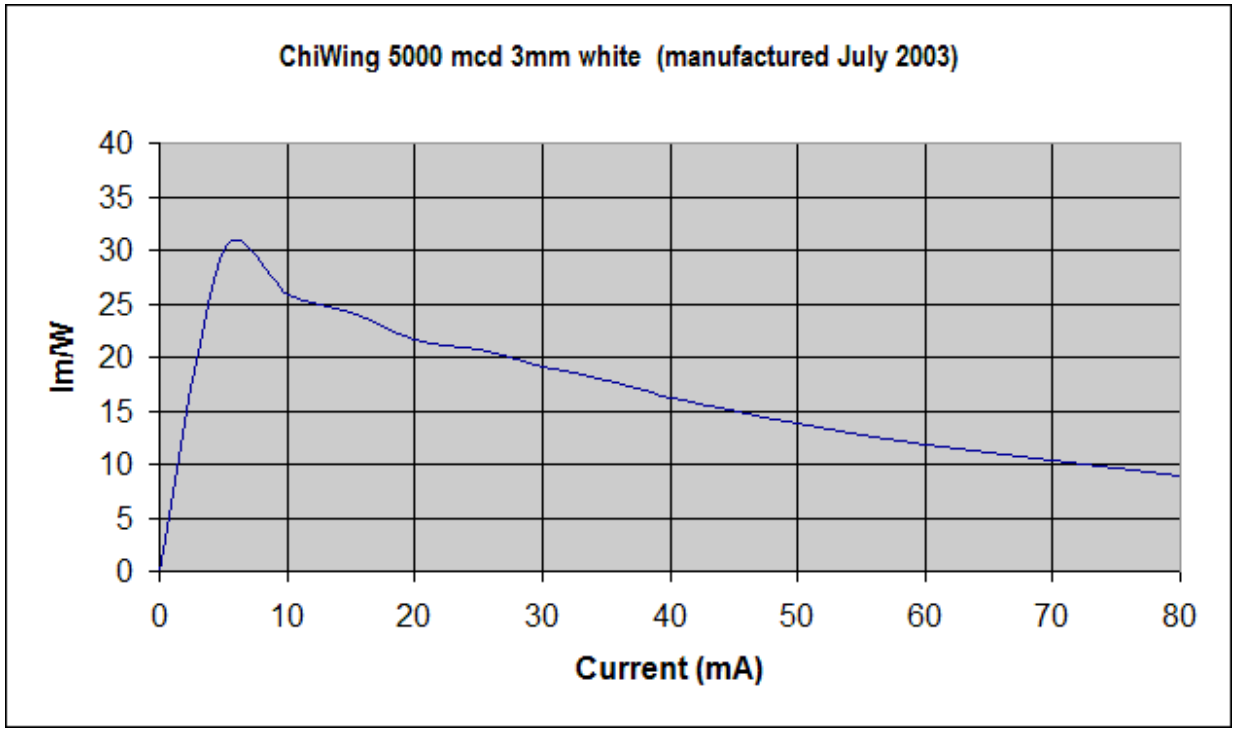
than this however. Since these are wide angle LEDs intensity wasn't very high, coming in at around 2,600 mcd at 20 mA. Half-intensity beam angle measured 51°. As with the other Nichias I've tested, these do well at higher currents, giving nearly 3 times their 20 mA output when driven at 100 mA. They might do even better soldered to a PC board with heavy traces. Efficiency was low for a white LED these days, coming in at 36.2 lm/W at 20 mA but peaking in the 50 lm/W area when driven at 2 to 5 mA. Nevertheless, 36 lm/W is still 4 to 10 times higher than the efficiencies of the grain of wheat incandescents which LEDs like this might be used to replace. The NSPW310CS, which is the newer, brighter version of this LED, would do about 65 lm/W based on the relative typical intensities given by Nichia.

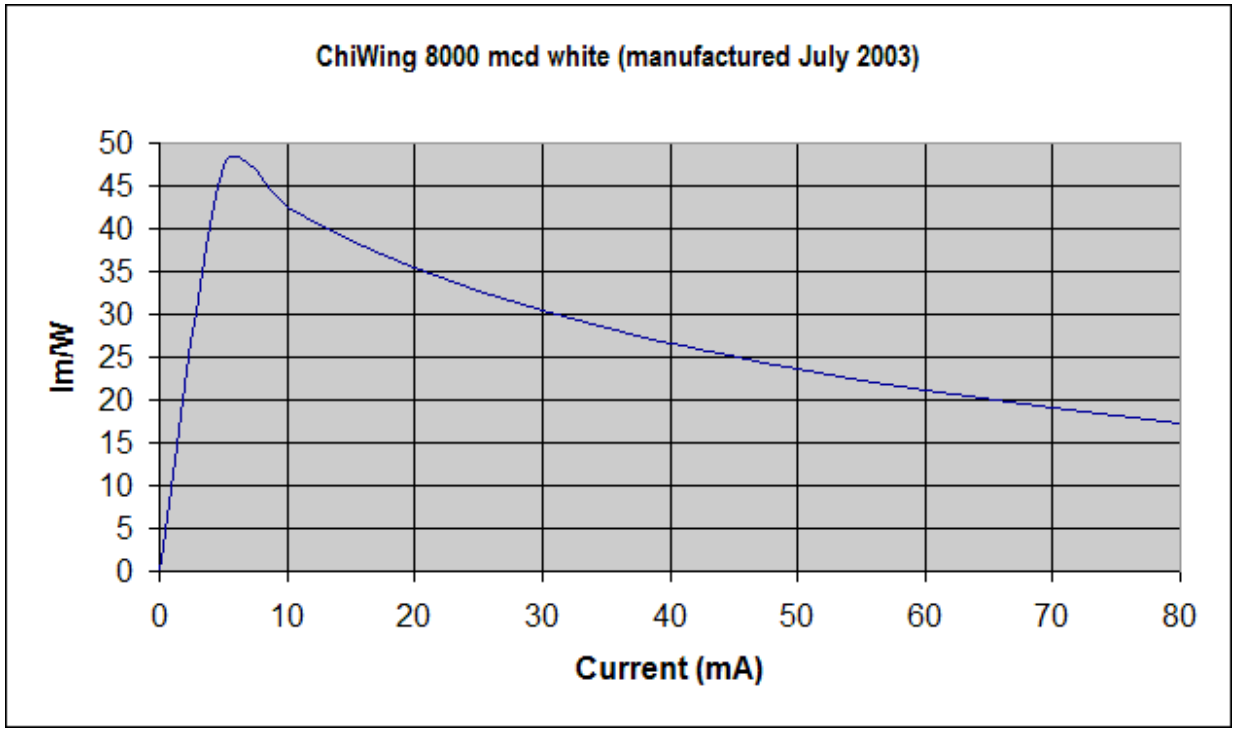
I'll be adding to this list as I acquire more white LEDs...

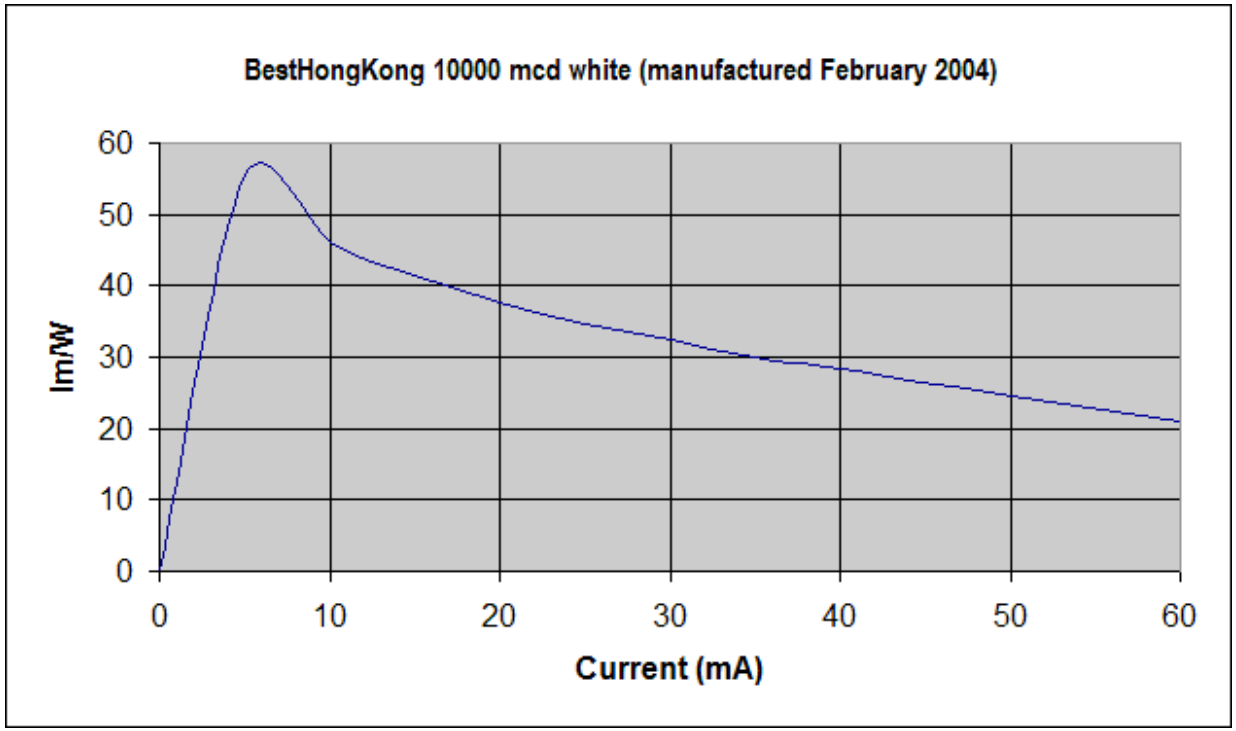
Here are the graphs for efficiency versus current:

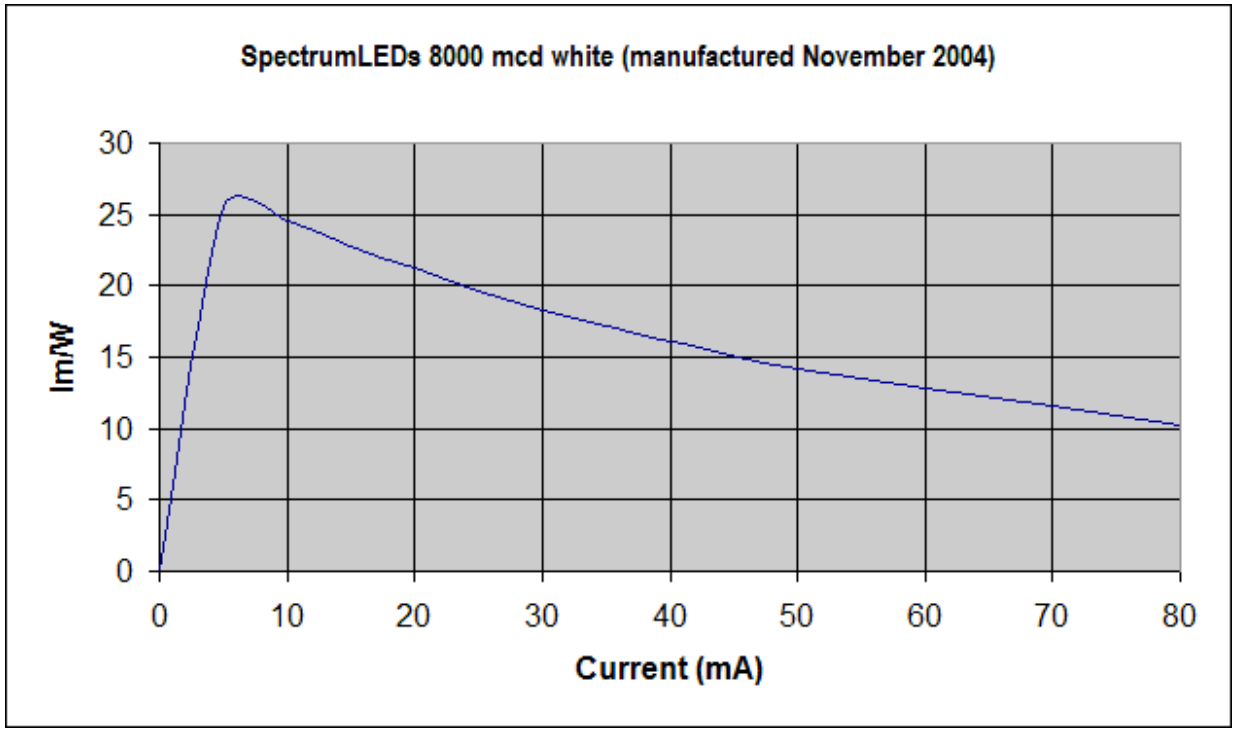


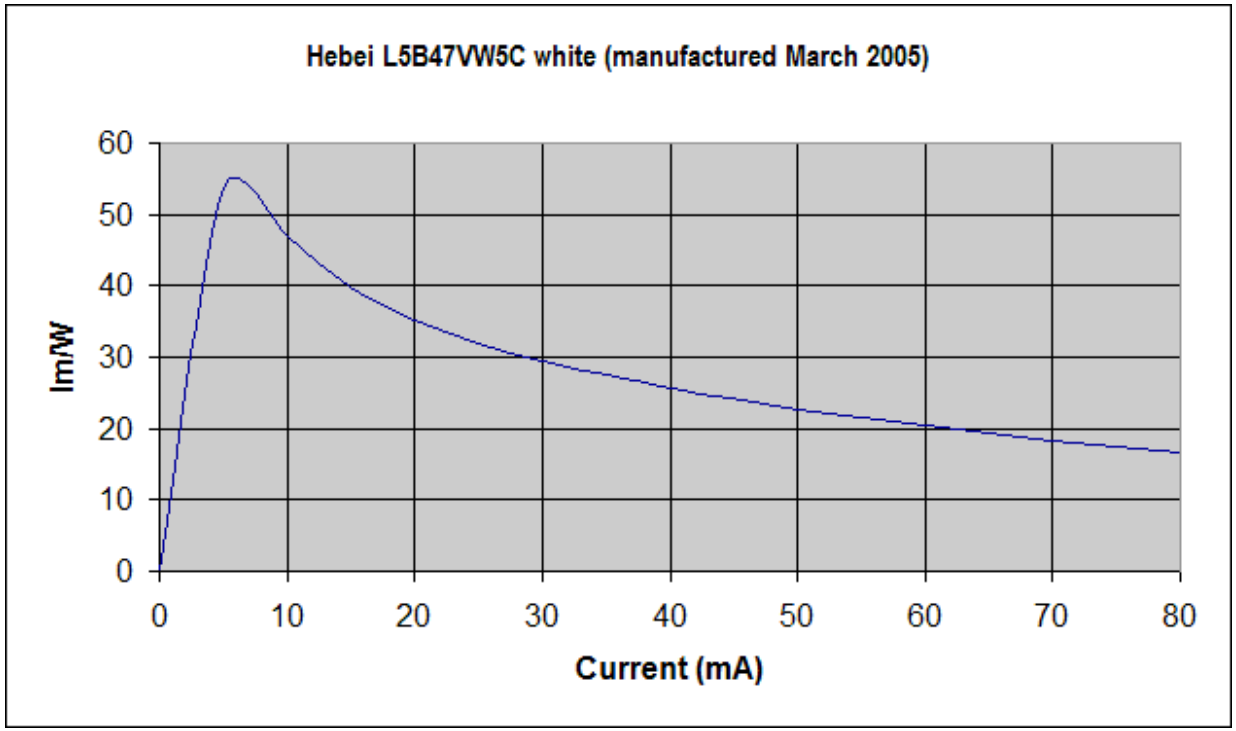

SpectrumLEDs 6000 mcd white (manufactured May 2003)
lm/W
30
25
20
15
10
5
0
0
10
20
30
40
50
60
70
80
Current (mA)

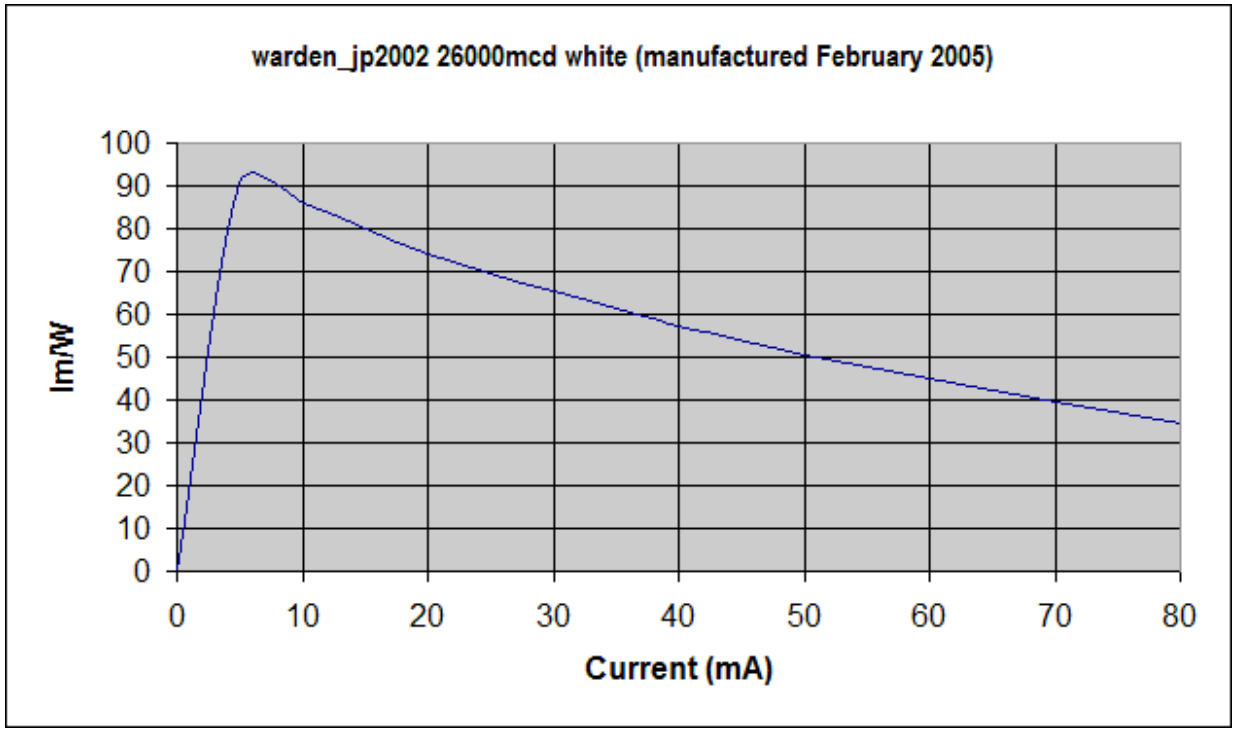

ChiWing 5000 mcd 3mm white (manufactured July 2003)
lm/W
40
35
30
25
20
15
10
5
0
0
10
20
30
40
50
60
70
80
Current (mA)

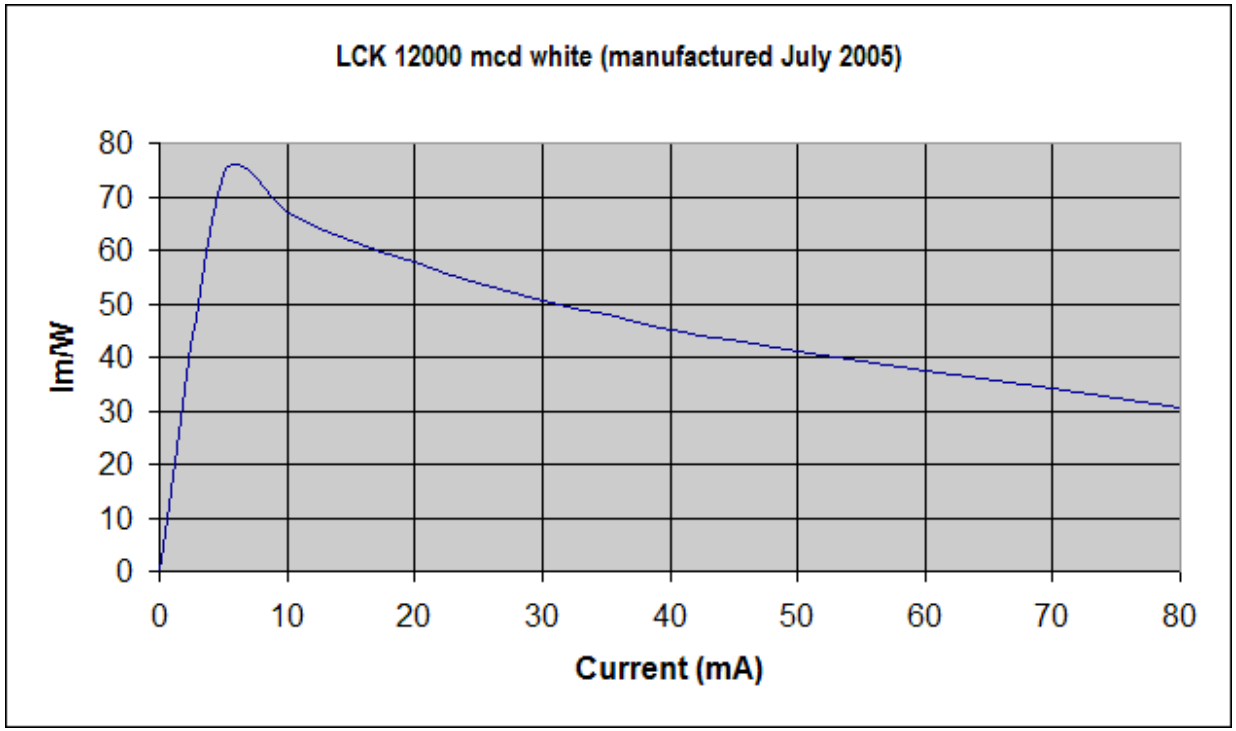

ChiWing 8000 mcd white (manufactured July 2003)
lm/W
50
45
40
35
30
25
20
15
10
5
0
0
10
20
30
40
50
60
70
80
Current (mA)

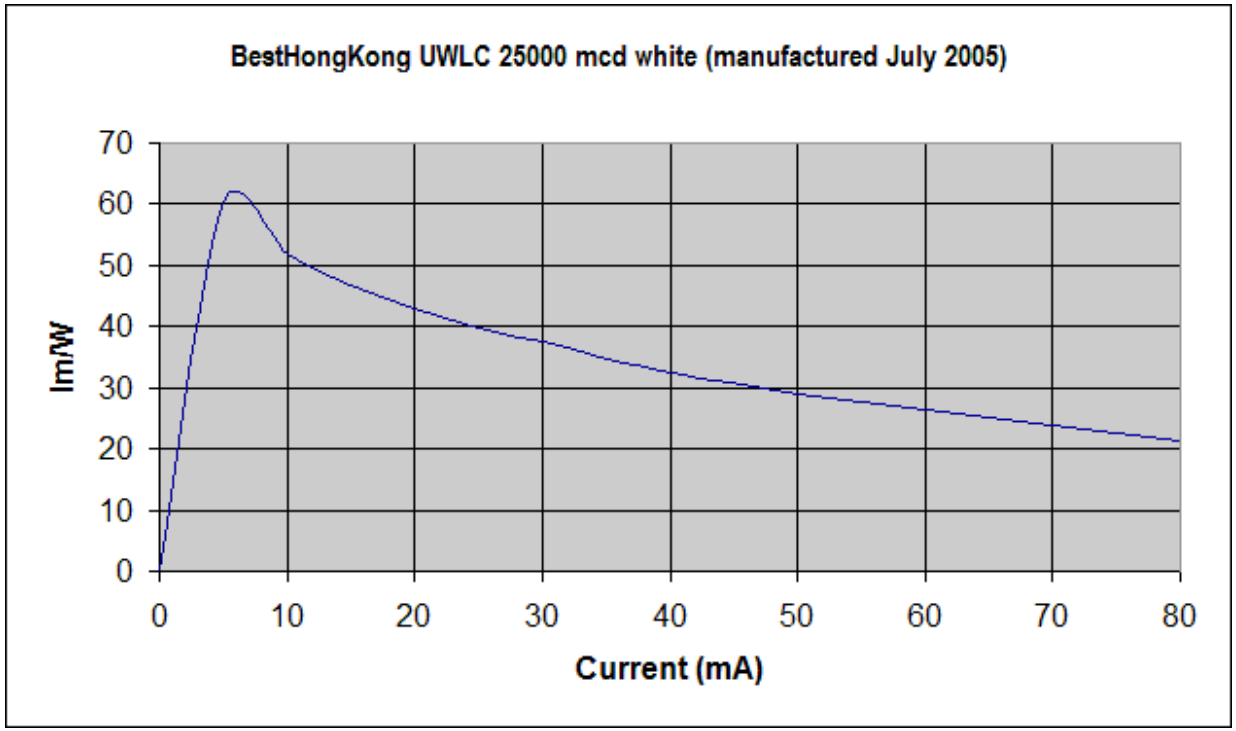

BestHongKong 10000 mcd white (manufactured February 2004)
lm/W
60
50
40
30
20
10
0
0
10
20
30
40
50
60
Current (mA)

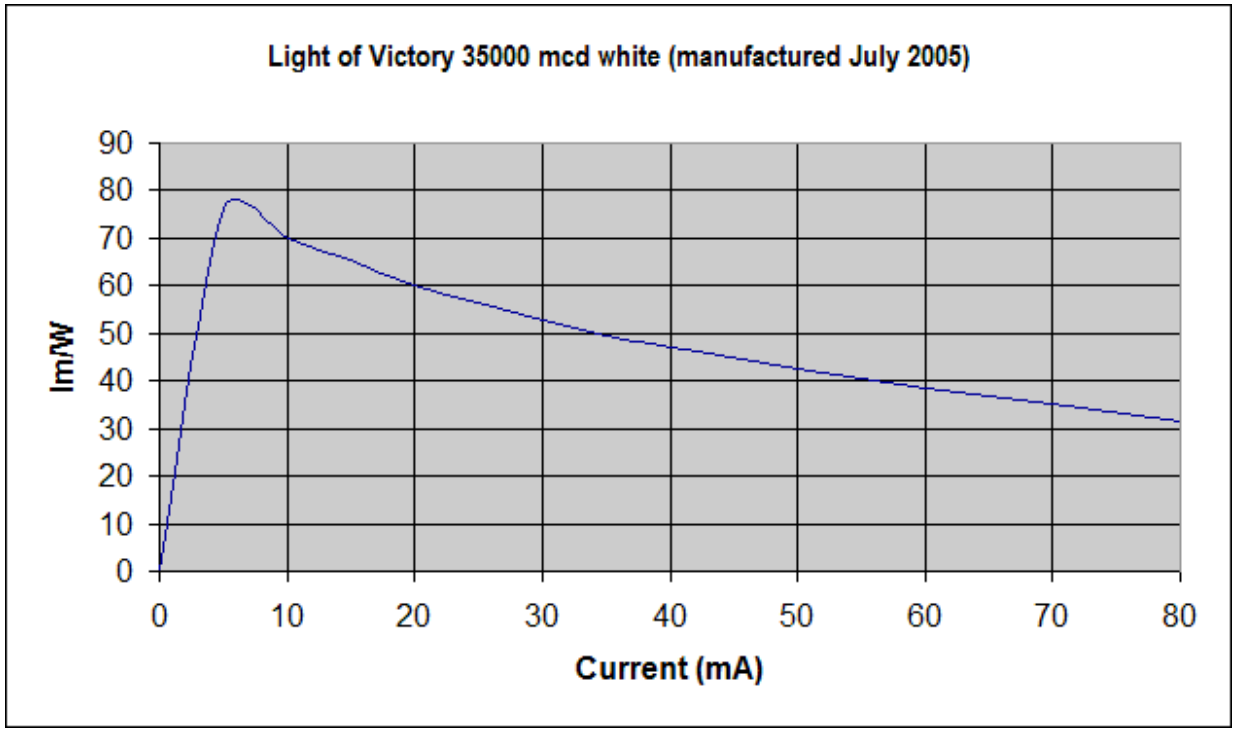

SpectrumLEDs 8000 mcd white (manufactured November 2004)
lm/W
30
25
20
15
10
5
0
0
10
20
30
40
50
60
70
80
Current (mA)

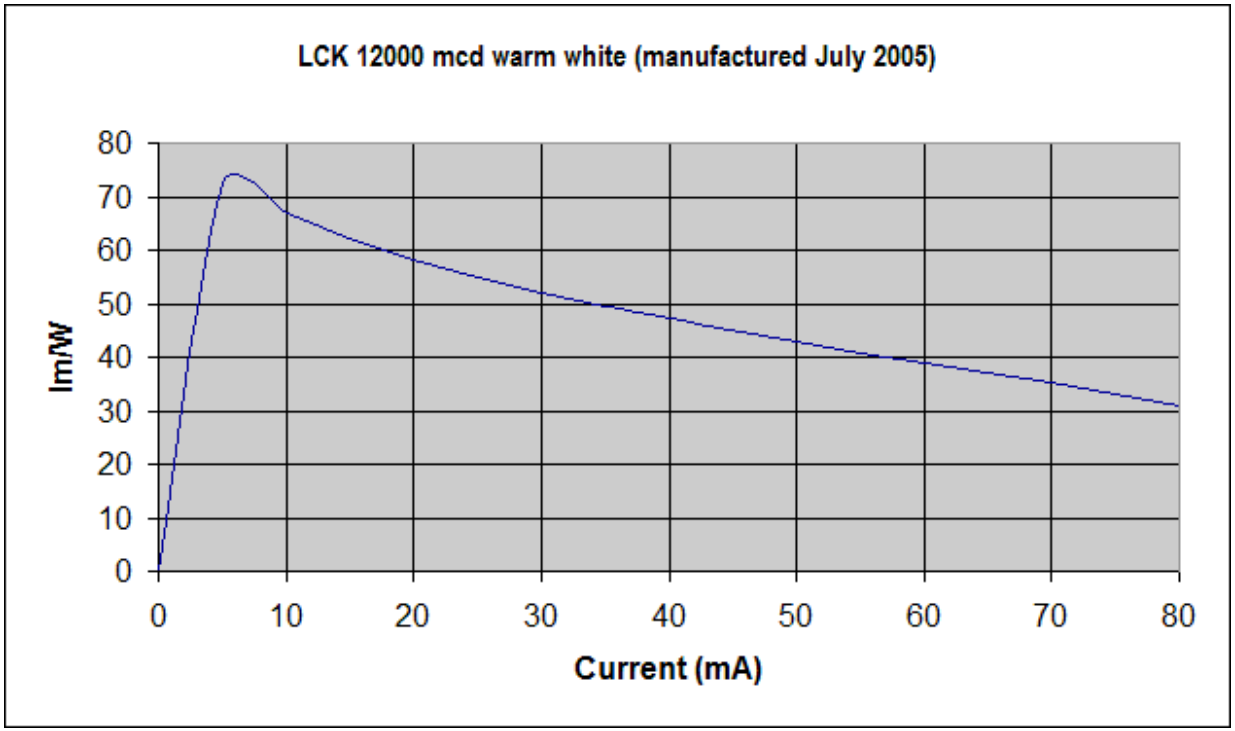

Hebei L5B47VW5C white (manufactured March 2005)
lm/W
60
50
40
30
20
10
0
0
10
20
30
40
50
60
70
80
Current (mA)

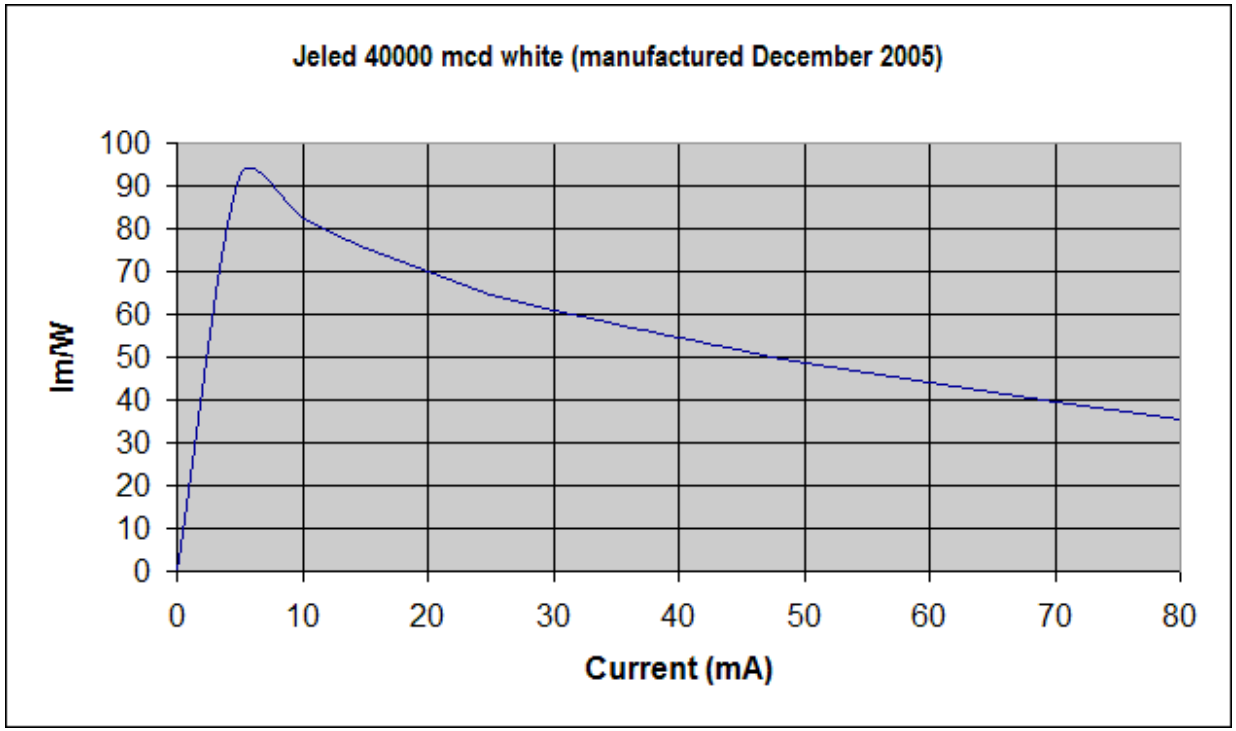

warden_jp2002 26000mcd white (manufactured February 2005)
lm/W
100
90
80
70
60
50
40
30
20
10
0
0
10
20
30
40
50
60
70
80
Current (mA)

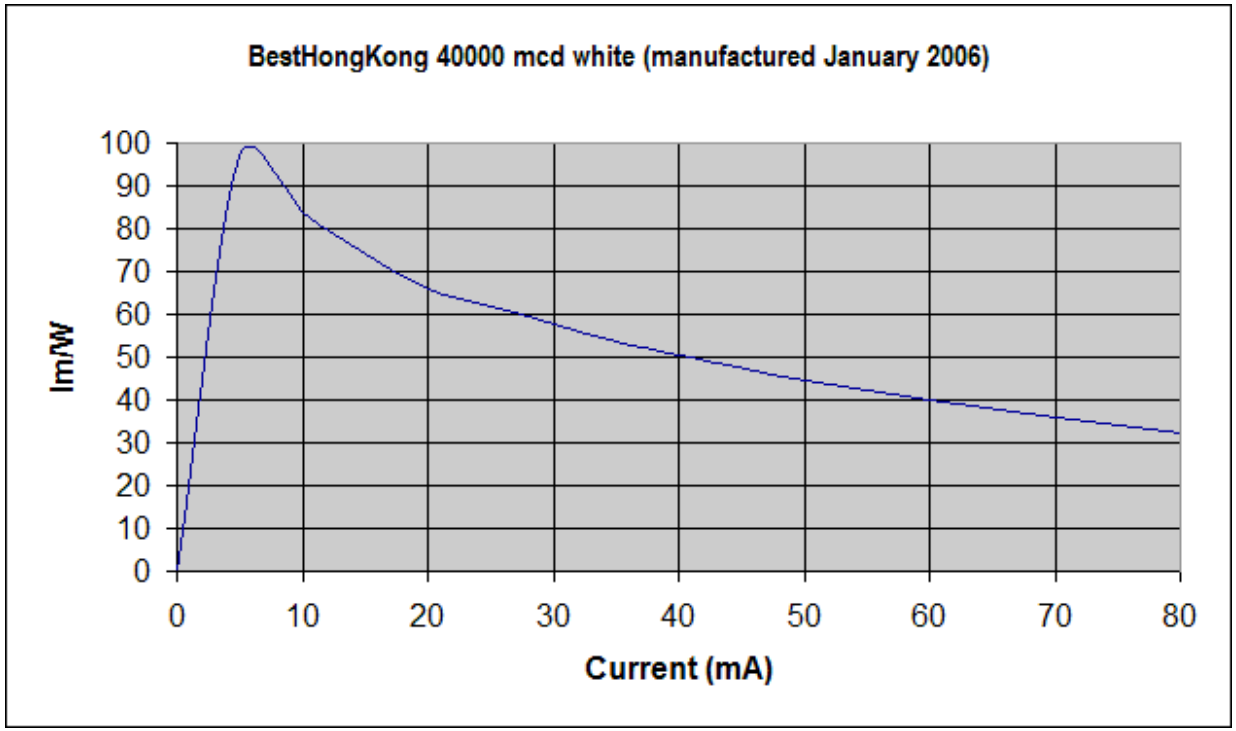

LCK 12000 mcd white (manufactured July 2005)
lm/W
80
70
60
50
40
30
20
10
0
0
10
20
30
40
50
60
70
80
Current (mA)


BestHongKong UWLC 25000 mcd white (manufactured July 2005)
lm/W
70
60
50
40
30
20
10
0
0
10
20
30
40
50
60
70
80
Current (mA)

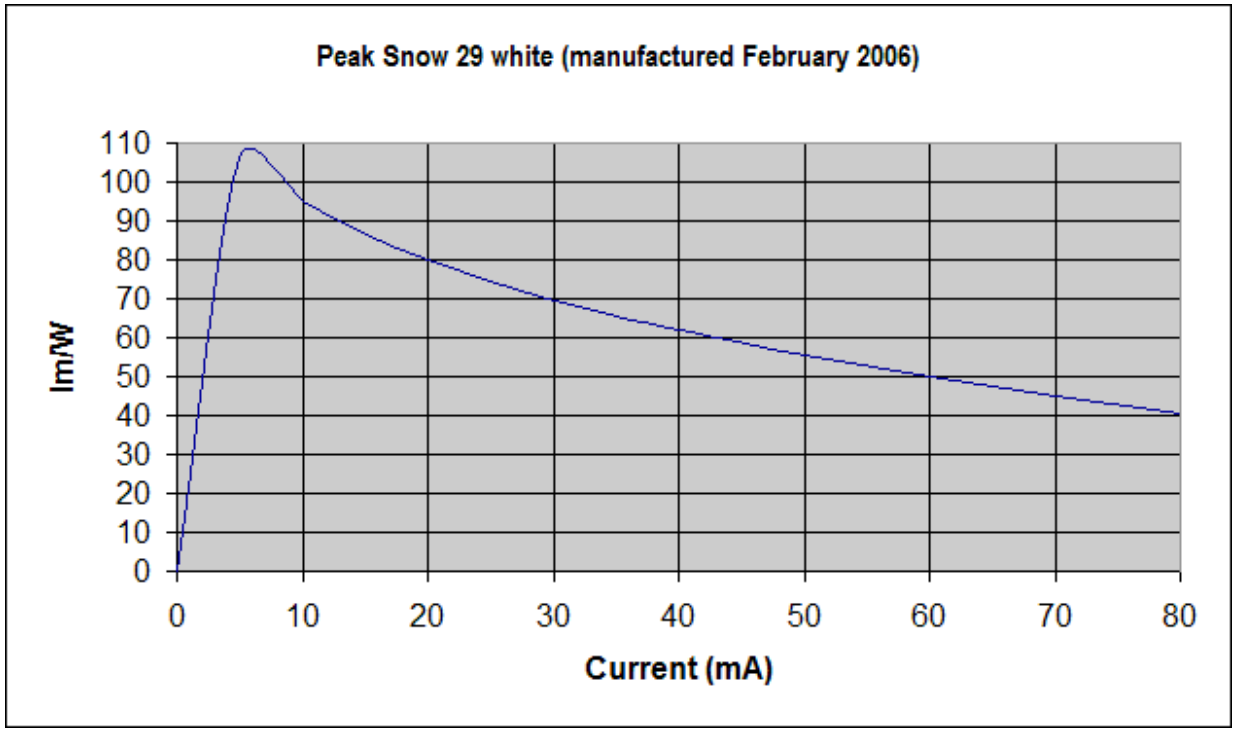

Light of Victory 35000 mcd white (manufactured July 2005)
lm/W
90
80
70
60
50
40
30
20
10
0
0
10
20
30
40
50
60
70
80
Current (mA)

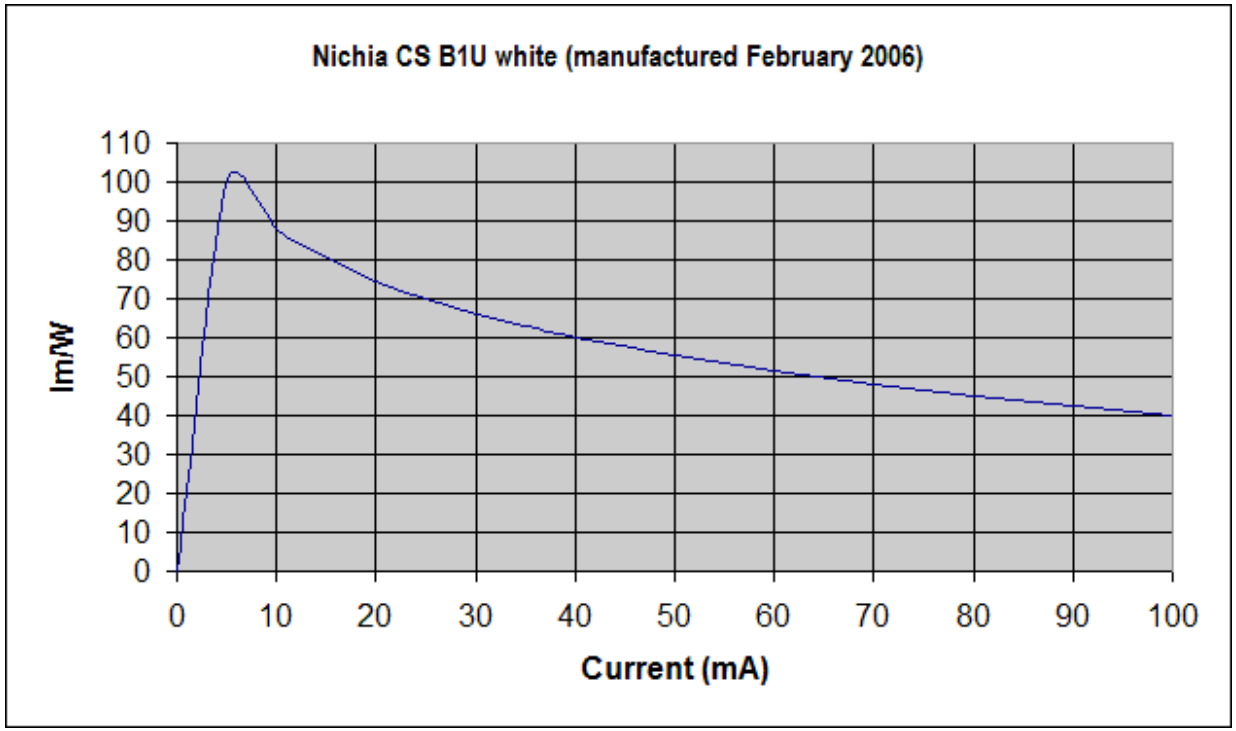

LCK 12000 mcd warm white (manufactured July 2005)
lm/W
80
70
60
50
40
30
20
10
0
0
10
20
30
40
50
60
70
80
Current (mA)

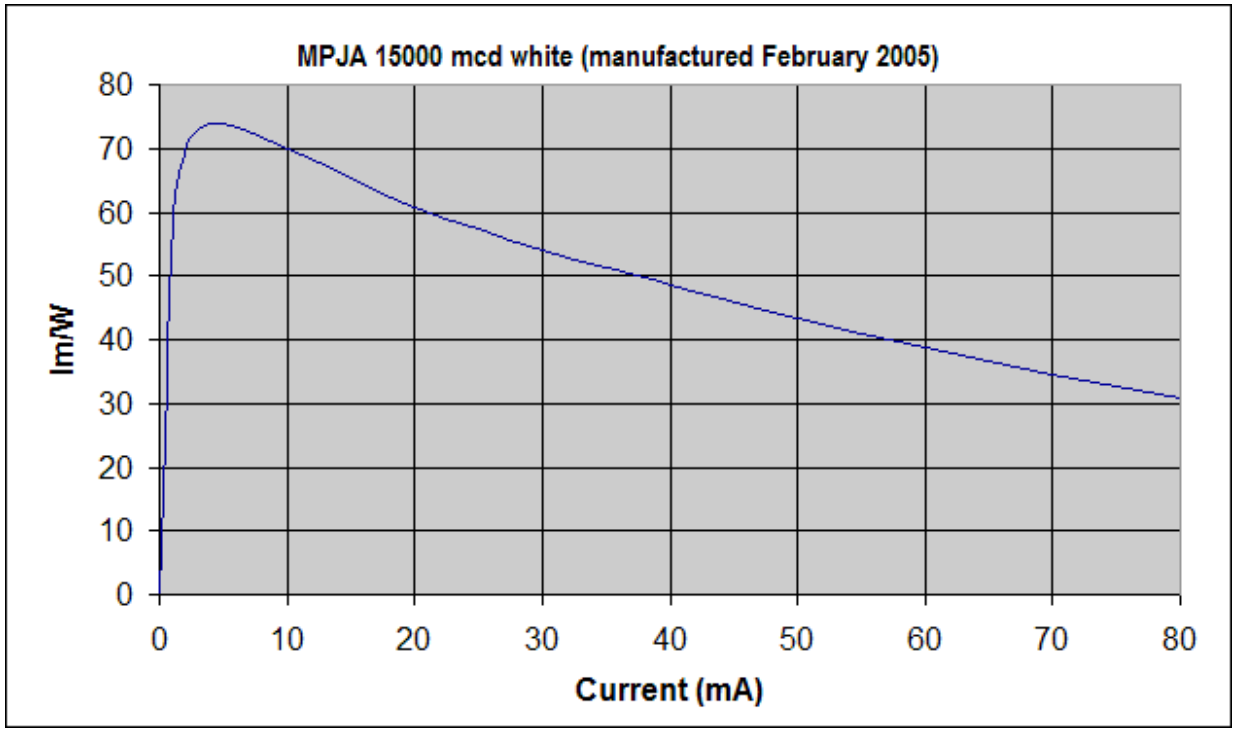

Jeled 40000 mcd white (manufactured December 2005)
lm/W
100
90
80
70
60
50
40
30
20
10
0
0
10
20
30
40
50
60
70
80
Current (mA)

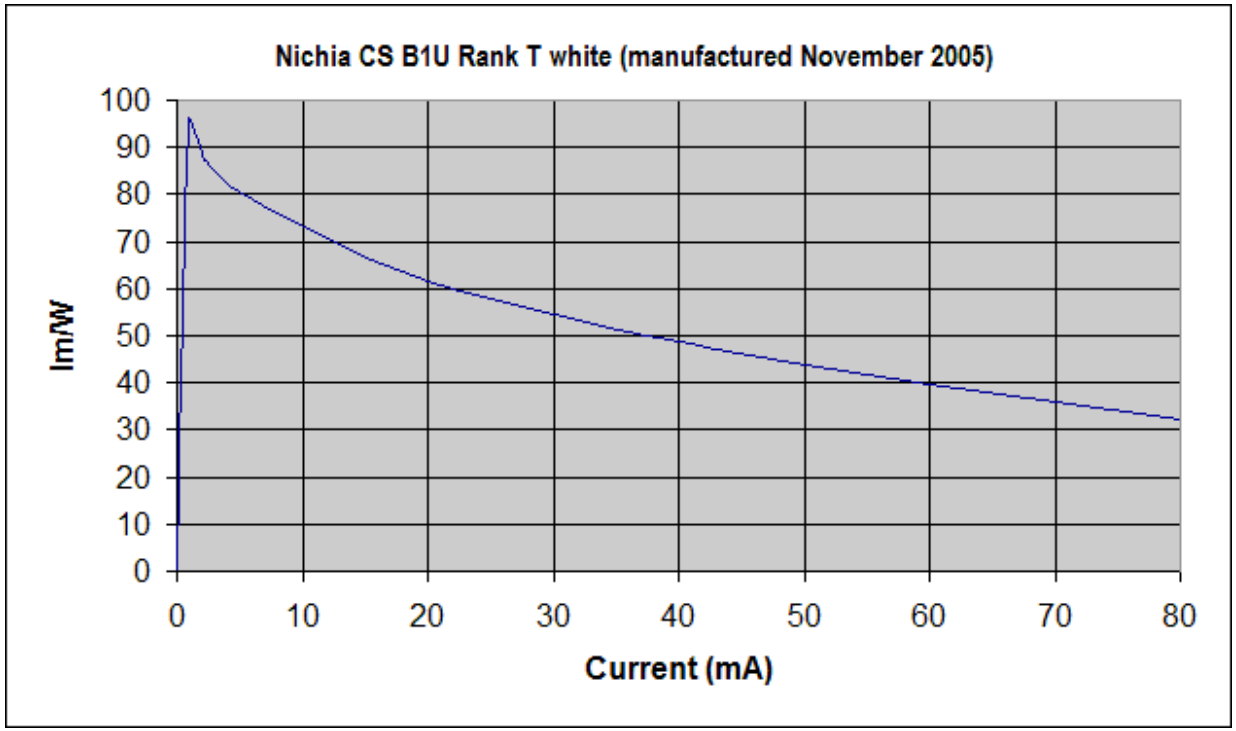

BestHongKong 40000 mcd white (manufactured January 2006)
lm/W
100
90
80
70
60
50
40
30
20
10
0
0
10
20
30
40
50
60
70
80
Current (mA)

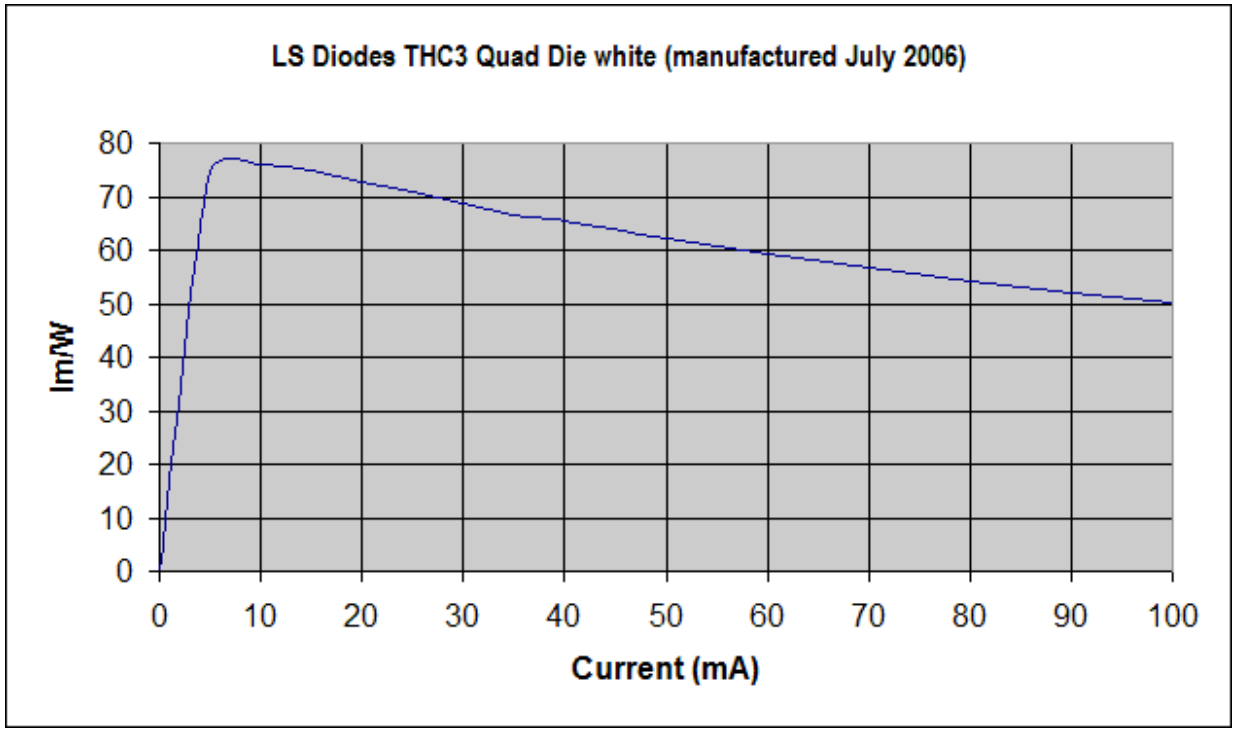

Jeled 50000 mcd white (manufactured January 2006)
lm/W
130
120
110
100
90
80
70
60
50
40
30
20
10
0
0
10
20
30
40
50
60
70
80
Current (mA)

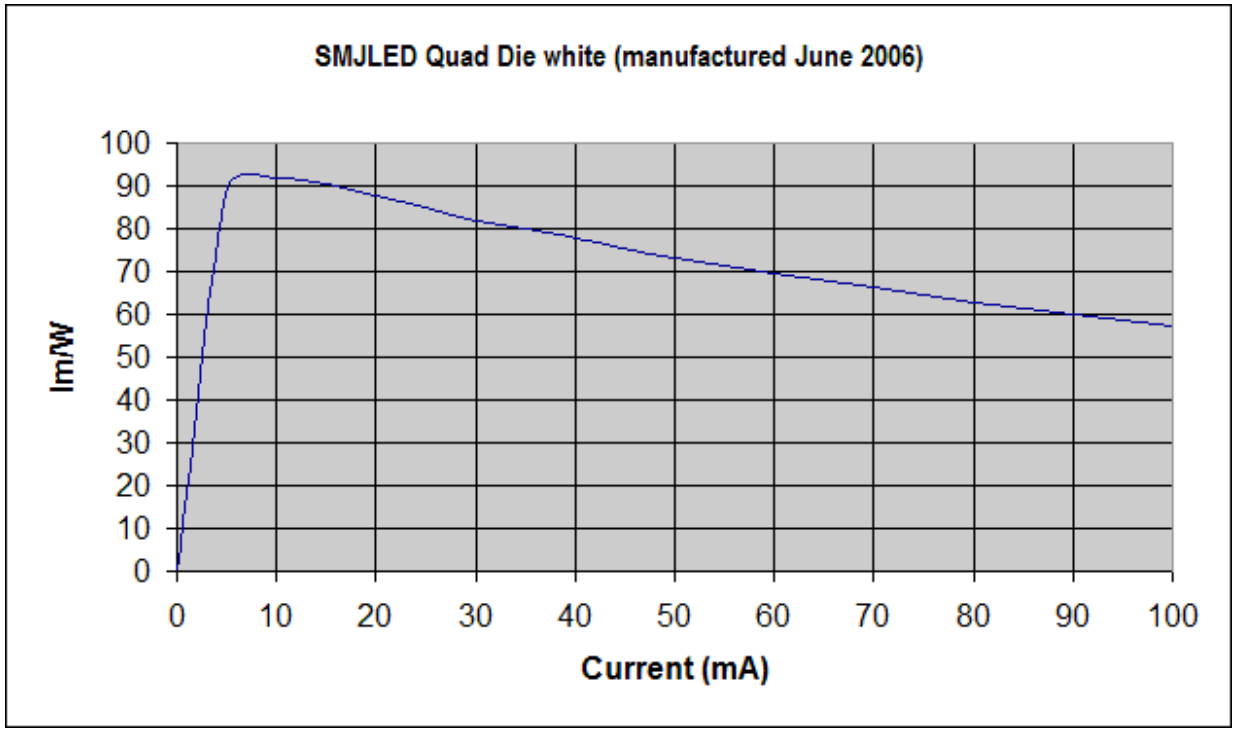

Peak Snow 29 white (manufactured February 2006)
lm/W
110
100
90
80
70
60
50
40
30
20
10
0
0
10
20
30
40
50
60
70
80
Current (mA)

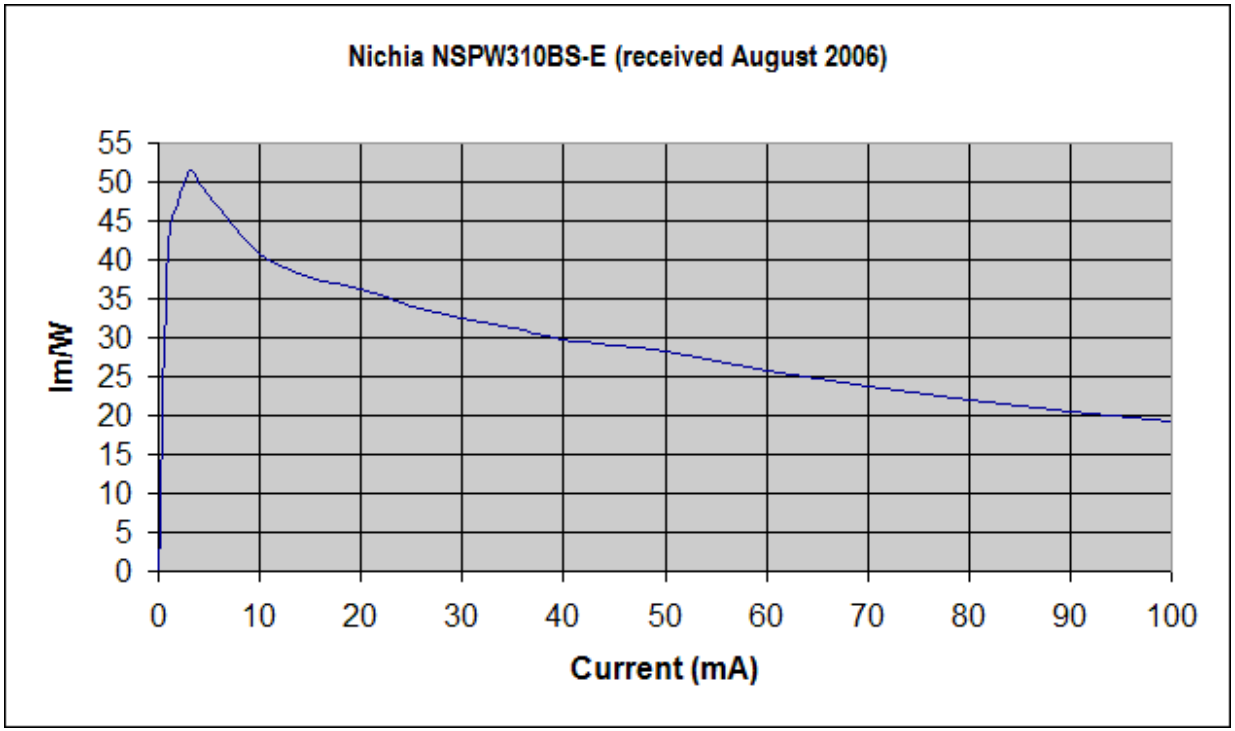

Nichia CS B1U white (manufactured February 2006)
lm/W
110
100
90
80
70
60
50
40
30
20
10
0
0
10
20
30
40
50
60
70
80
90
100
Current (mA)


MPJA 15000 mcd white (manufactured February 2005)
lm/W
80
70
60
50
40
30
20
10
0
0
10
20
30
40
50
60
70
80
Current (mA)

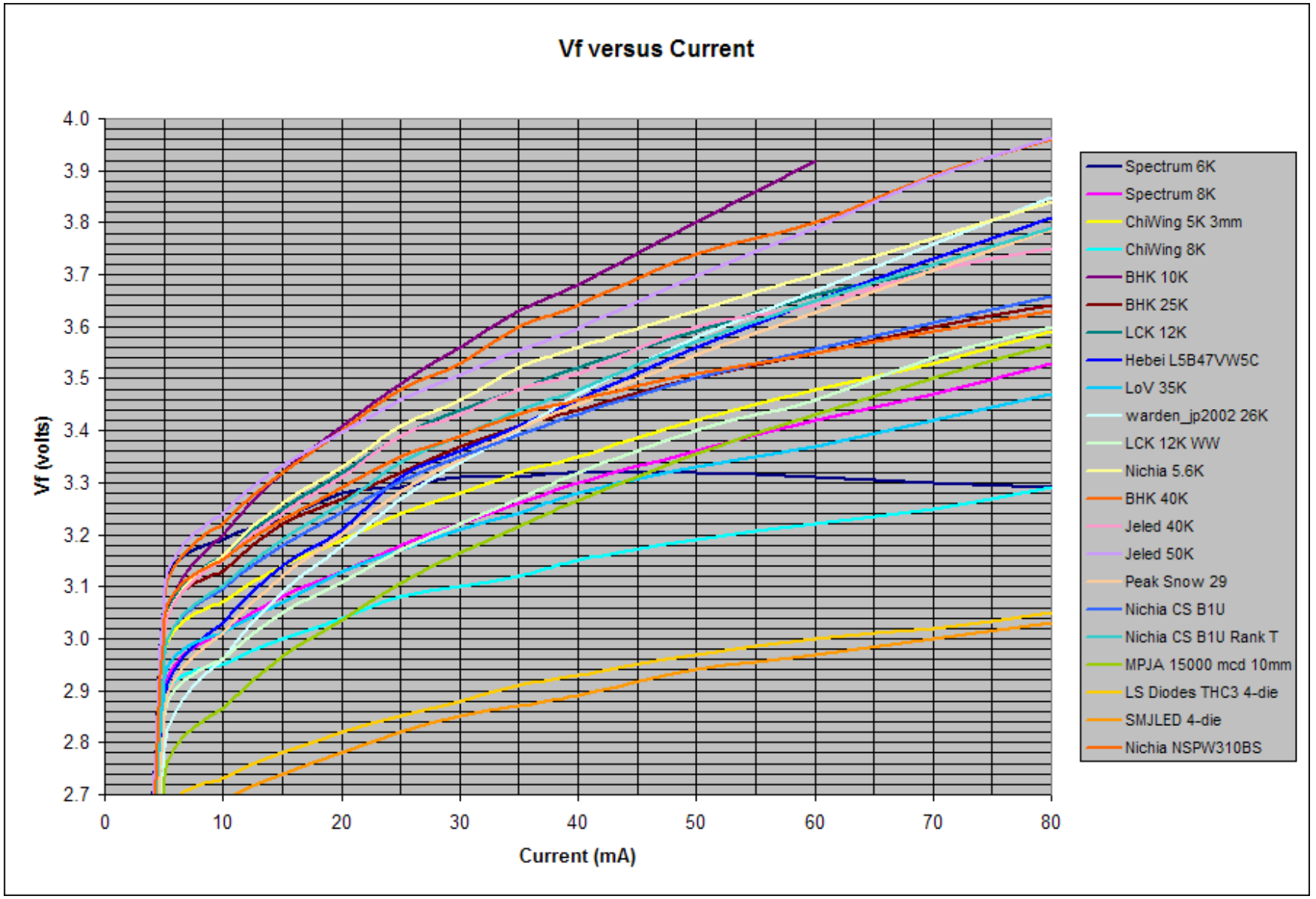

Nichia CS B1U Rank T white (manufactured November 2005)
lm/W
100
90
80
70
60
50
40
30
20
10
0
0
10
20
30
40
50
60
70
80
Current (mA)

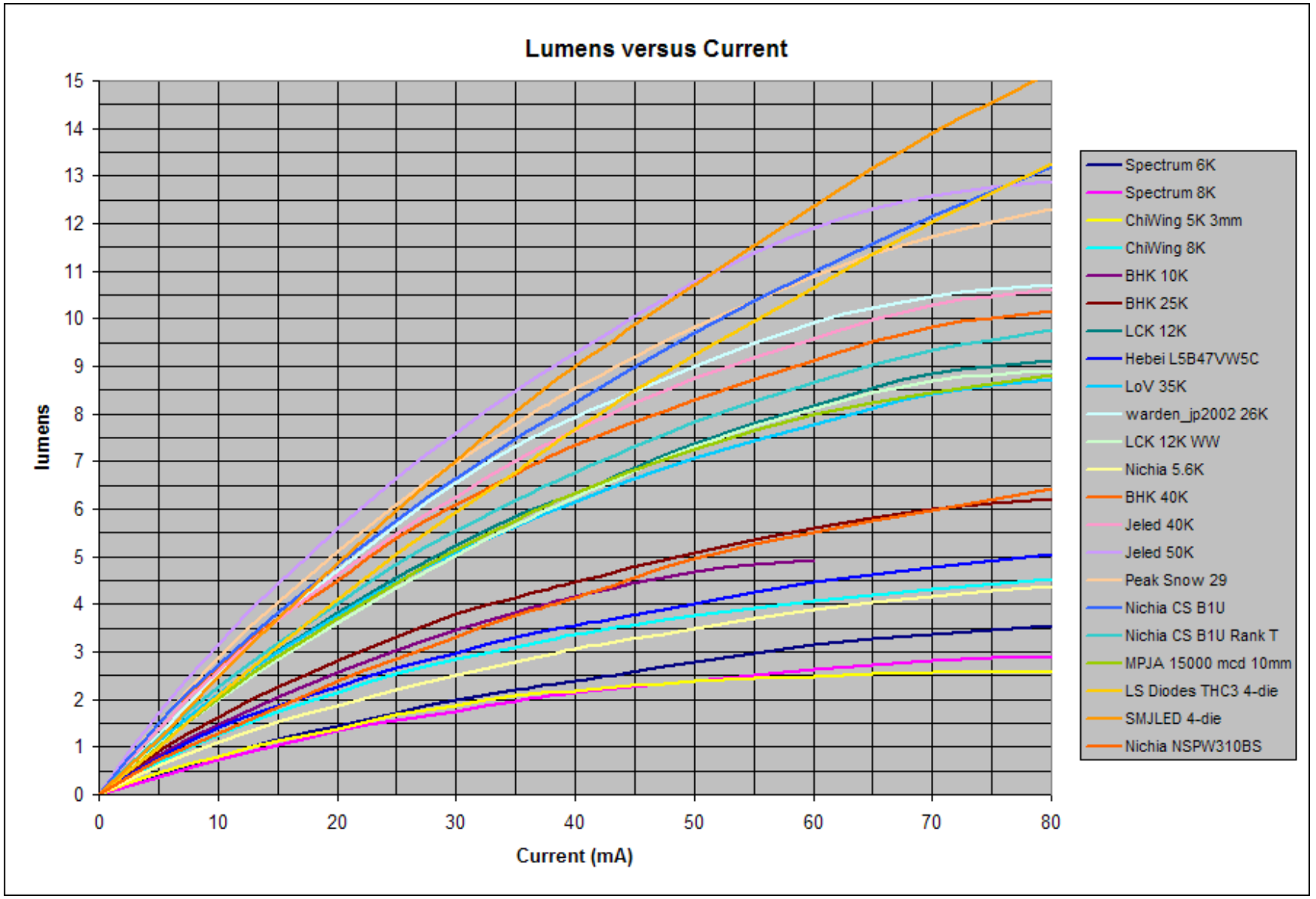

LS Diodes THC3 Quad Die white (manufactured July 2006)
lm/W
80
70
60
50
40
30
20
10
0
0
10
20
30
40
50
60
70
80
90
100
Current (mA)

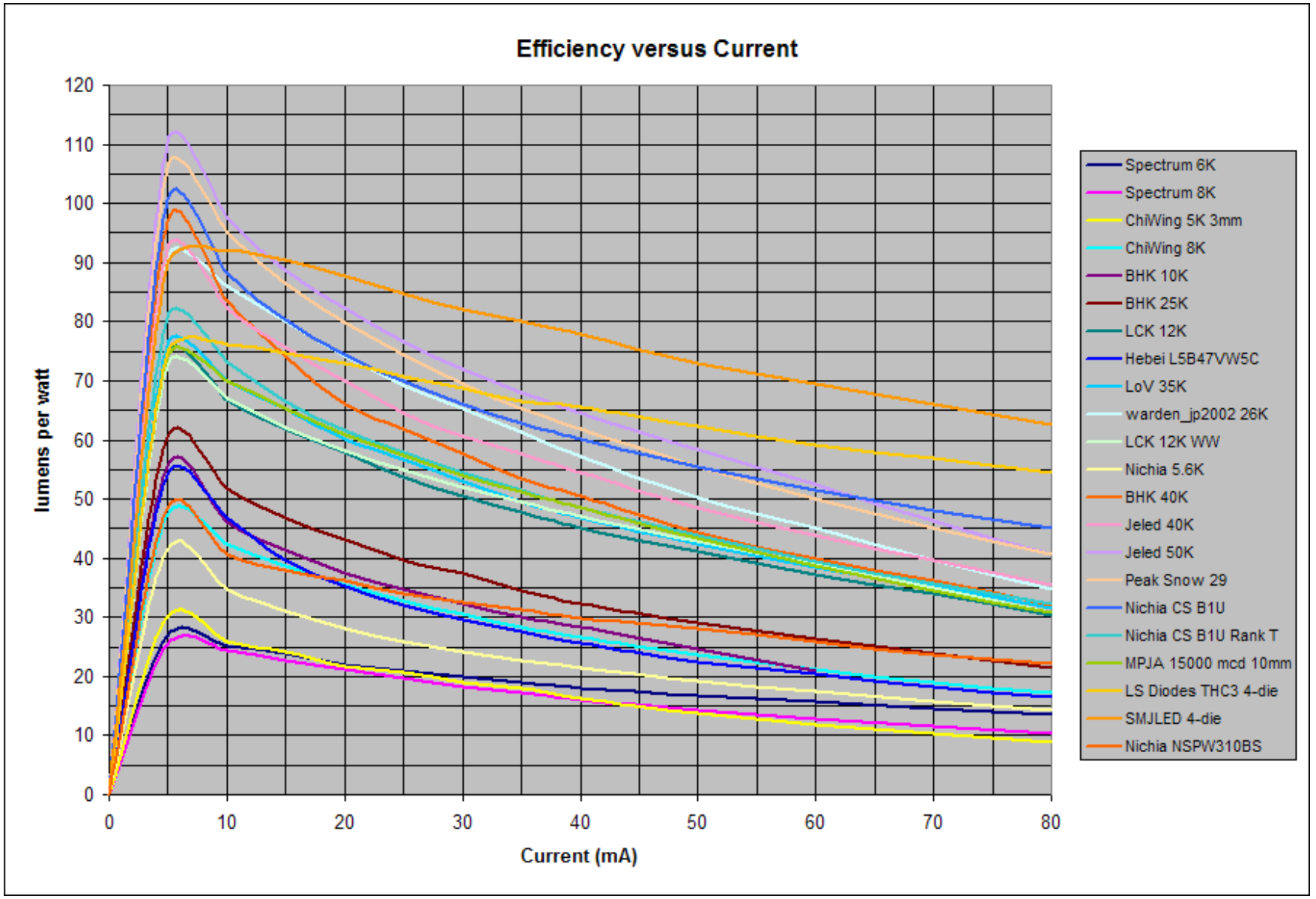

SMJLED Quad Die white (manufactured June 2006)
lm/W
100
90
80
70
60
50
40
30
20
10
0
0
10
20
30
40
50
60
70
80
90
100
Current (mA)

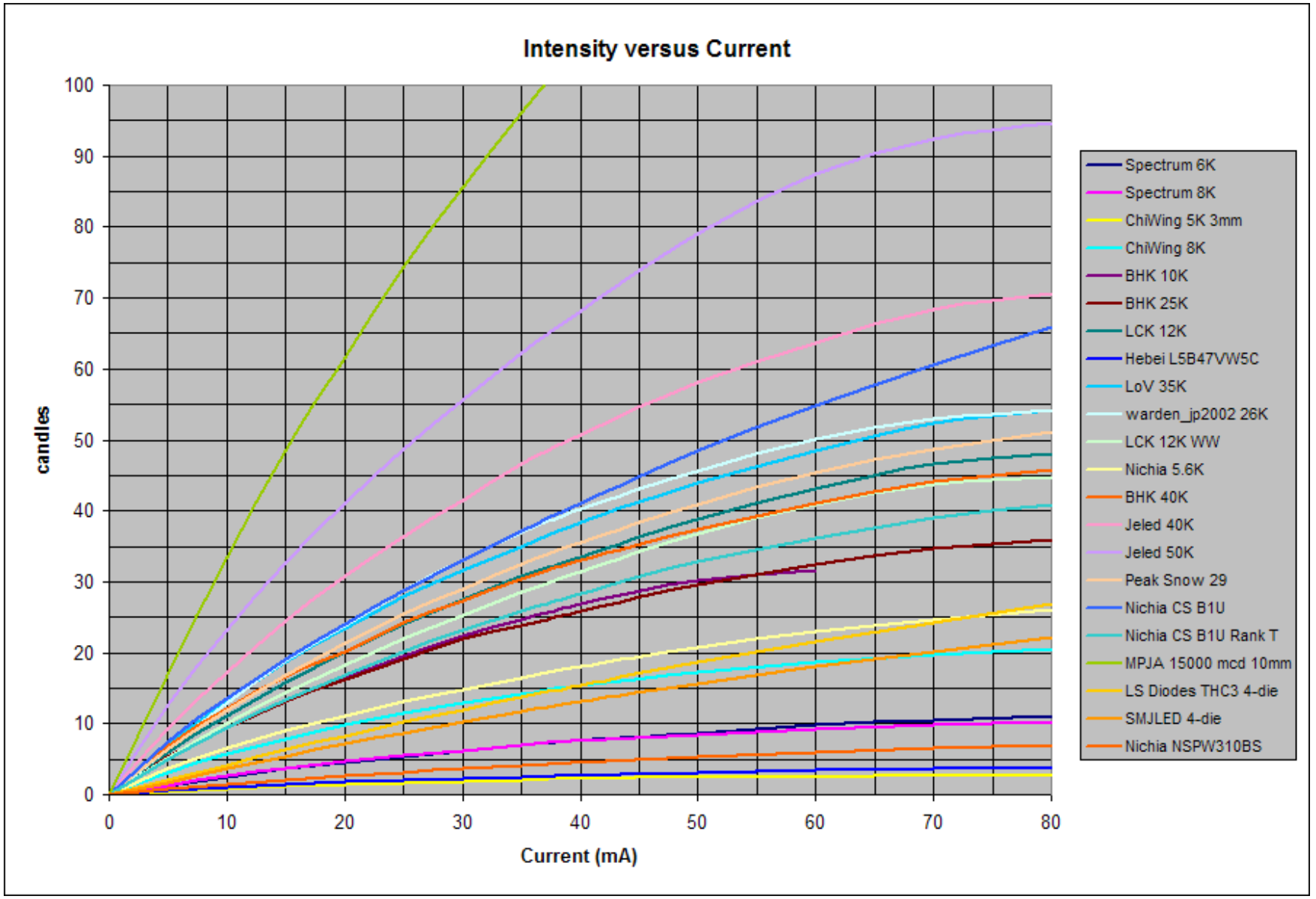


Here is a series of head-to-head comparisons of all the LEDs for a number of different parameters:


Vf versus Current
Vf (volts)
4.0
3.9
3.8
3.7
3.6
3.5
3.4
3.3
3.2
3.1
3.0
2.9
2.8
2.7
0
10
20
30
40
50
60
70
80
Current (mA)
Spectrum 6K
Spectrum 8K
ChiWing 5K 3mm
ChiWing 8K
BHK 10K
BHK 25K
LCK 12K
Hebei L5B47VW5C
LoV 35K
warden_jp2002 26K
LCK 12K WW
Nichia 5.6K
BHK 40K
Jeled 40K
Jeled 50K
Peak Snow 29
Nichia CS B1U
Nichia CS B1U Rank T
MPJA 15000 mcd 10mm
LS Diodes THC3 4-die
SMJLED 4-die
Nichia NSPW310BS


Lumens versus Current
lumens
Current (mA)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
0
10
20
30
40
50
60
70
80
Spectrum 6K
Spectrum 8K
ChiWing 5K 3mm
ChiWing 8K
BHK 10K
BHK 25K
LCK 12K
Hebei L5B47VW5C
LoV 35K
warden_jp2002 26K
LCK 12K WW
Nichia 5.6K
BHK 40K
Jeled 40K
Jeled 50K
Peak Snow 29
Nichia CS B1U
Nichia CS B1U Rank T
MPJA 15000 mcd 10mm
LS Diodes THC3 4-die
SMJLED 4-die
Nichia NSPW310BS


Efficiency versus Current
lumens per watt
Current (mA)
0
10
20
30
40
50
60
70
80
90
100
110
120
Spectrum 6K
Spectrum 8K
ChiWing 5K 3mm
ChiWing 8K
BHK 10K
BHK 25K
LCK 12K
Hebei L5B47VW5C
LoV 35K
warden_jp2002 26K
LCK 12K WW
Nichia 5.6K
BHK 40K
Jeled 40K
Jeled 50K
Peak Snow 29
Nichia CS B1U
Nichia CS B1U Rank T
MPJA 15000 mcd 10mm
LS Diodes THC3 4-die
SMJLED 4-die
Nichia NSPW310BS



Note how there is more or less (with the exception of the SpectrumLEDs 8000 mcd white) a steady improvement in efficiency from 2003 until the present. Most of the LEDs clustered together in the efficiency graphs were purchased at roughly the same time.

Here is a chart summarizing the results at 20 mA test current:

LED	Beam angle	Vf (volts)	Intensity (mcd)	Output (lumens)	Efficiency (lm/W)	Date Tested	Date of Manufacture
Nichia 5600 mcd 5mm	13.9°	3.33	11100	1.87	28.1	July 2005	2001
Spectrum LEDs 6000 mcd 5mm	17.3°	3.28	4500	1.44	22.0	July 2005	May 2003
ChiWing 5000 mcd 3mm	32.6°	3.19	1400	1.38	21.7	July 2005	July 2003
ChiWing 8000 mcd 5mm	15.2°	3.04	9800	2.15	35.4	July 2005	July 2003
BestHongKong 10000 mcd 5mm	11.8°	3.41	16500	2.56	37.5	July 2005	February 2004
Spectrum LEDs 8000 mcd 5mm	16.0°	3.13	4700	1.33	21.3	July 2005	November 2004
wardenjp_2002 26000 mcd 5mm	16.0°	3.18	23900	4.72	74.2	July 2005	February 2005
Hebei L5B47VW5C 60° 5mm	61.3°	3.21	1750	2.26	35.2	July 2005	March 2005
LCK 12000 mcd 5mm	13.3°	3.32	20200	3.84	57.8	July 2005	July 2005
BestHongKong 25000 mcd 5mm UWLC series	14.5°	3.27	16300	2.81	43.0	July 2005	July 2005
Light of Victory 35000 mcd 5mm	13.7°	3.13	23400	3.76	60.1	July 2005	July 2005
LCK warm white 12000 mcd 5mm	15.5°	3.11	18200	3.61	58.1	July 2005	July 2005
Jeled 40000 mcd 5mm	13.2°	3.31	30800	4.64	70.0	December 2005	December 2005
BestHongKong 40000 mcd 5mm	16.9°	3.40	20200	4.50	66.1	January 2006	January 2006
Jeled 50000 mcd 5mm	12.8°	3.40	41100	5.59	82.3	January 2006	January 2006
Peak Snow 29 5mm	16.7°	3.20	21300	5.11	79.8	February 2006	February 2006
Nichia CS bin B1U 5mm	16.2°	3.24	24100	4.83	74.5	February 2006	February 2006
MPJA 15000 mcd 10mm	8.4°	3.04	61700	3.69	60.9	July 2006	February 2005
unknown 26000 mcd 5mm	17.2°	3.26	16800	4.02	61.6	July 2006	November 2005
LS Diodes THC3 quad-die 5mm	27.4°	2.82	8300	4.11	72.8	July 2006	July 2006
SMJLED quad-die 5mm	31.6°	2.78	7100	4.88	87.8	July 2006	June 2006
Nichia NSPW310BS-E 60° 3mm	50.9°	3.29	2600	2.38	36.2	August 2006	August 2006

As to the accuracy of my results, for a sanity check the Light of Victory 35,000 mcd seem a close match to the Nichia CS in terms of intensity and lumens, and the Nichias are supposed to have efficiencies in the 60 lm/W area at 20 mA. This is exactly where the Light of Victory 35,000 mcd falls. The warden_jp2002 actually is around 74 lm/W at 20 mA. I'm guessing someone got a supply a Cree's XT-24 chips for those. Nothing else could give efficiencies that high. Also note how these same LEDs break 90 lm/W at 5 mA. (Nothing thus far has beat these LEDs, which were available for a fairly short time on eBay.) - Note: *The warden_jp2002 LEDs were finally beaten by the Jeled 50000 mcd ones, but they held the record for nearly a year.*

Last edited by jtr1962 : Yesterday at 06:29 PM.

08-07-2005, 01:43 PM #2

chimo
Flashaholic*

Join Date: Sep 2004
Location: Ottawa, Canada
Posts: 1,314

Re: White LED lumen testing

jtr1962, great work! I d/l'd the zip file but I got errors in it. Could you check it out? I would like to compare you data to mine. Thanks,

Pual

Quote

08-07-2005, 01:51 PM #3

jtr1962
Flashaholic*

Join Date: Nov 2003
Location: Flushing, NY
Posts: 1,925

Re: White LED lumen testing

Yeah, were right about the error Paul. I fixed it so just download it again.

Quote

08-07-2005, 01:59 PM #4

chimo
Flashaholic*

Join Date: Sep 2004
Location: Ottawa, Canada
Posts: 1,314

Re: White LED lumen testing

Got the new copy. Thanks!

Paul

Quote

08-07-2005, 02:24 PM #5

tvodrd

CPF Diamond Supporter

Join Date: Dec 2002
Location: Costa Mesa, CA
Posts: 4,916

Re: White LED lumen testing

Wow! [img]/ubbthreads/images/graemlins/thumbsup.gif[/img] and thanks!

Larry

Quote

08-07-2005, 02:50 PM #6

evan9162
Flashaholic*

Join Date: Apr 2002
Location: Boise, ID
Posts: 2,138

Re: White LED lumen testing

How are you generating a lumens value from the set of lux measurements? Are you doing a series of spherical caps, and summing up the intensity/area for each cap to get a total lumen output?

I was thinking of doing this a while ago, but never got around to it - I wanted to see how accurate my lumens coefficient was, and how close the lumileds datasheet was in reagards to the beam pattern of a luxeon high done.

Quote

08-07-2005, 03:08 PM #7

jtr1962
Flashaholic*

Join Date: Nov 2003
Location: Flushing, NY
Posts: 1,925

Re: White LED lumen testing

Yes evan9162, that's exactly how I'm doing it. For example, I take the relative lux readings for 0° and 5°, average them, multiply by the area in steradians, and then multiply by the intensity in candelas. After that, I'll do the same with the 5° and 10° values, etc, and add this to my running total. It's interesting that for narrow viewing angle (i.e. 15° or 20°) LEDs the traditional methods of calculating lumens in the main beam grossly underestimates the output. One can see why by examining the radiation pattern of one of these LEDs. Some light falls outside the main beam but this decreases in intensity rather quickly. Still, since the spherical area is larger as the angle increases, this spill still makes significant contributions to

the output. After that you usually have a bright ring about 60° off axis. This shows up clearly in the graphs in my spreadsheets. While the intensity might only be 2% or 3% of the maximum intensity, it is spread over a large area and contributes a good 15% to 20% of the total output. Finally, a great deal of light actually makes it out the back because of reflection off the front lens. This could easily add another 10% to 15% to total output. I was honestly amazed by this myself although it makes sense. For example, using the usual way of figuring lumens, and assuming a 20° beam angle, I might have guestimated about 2.3 lumens for the Light of Victory 35,000 mcd LED based on it's peak intensity reading of ~24,000 mcd at 20 mA (the 35,000 mcd spec is at 30 mA according to the manufacturer). I usually multiplied this by 1.25 to account for spill outside the main beam, giving me a final estimate of 2.9 lumens. The actual measurements come out to 3.75 to 3.9 based on a few samples, or over 30% more. I guess I'll revise my adhoc mutliplier to about 1.65 to give a more realistic estimate.

I'll also add that since the dial is just screwed to the tester and easily removeable, I might make another one up complete with a heat sink and mounting area to test Luxeons, Lamina BL-2000s, and other power LEDs. My constant current source can supply up to 2 amps if need be. I can verify my methodology if I get lumen measurements in the mid 30s with my Q-bin Luxeons.

Quote

08-07-2005, 05:43 PM #8

PeterB
Flashaholic*

Join Date: May 2003
Location: Germany
Posts: 605

Re: White LED lumen testing

Great data collection!
And the warden_jp2002 data fits quite well to my old measurements with a completely different method (I had also these warden LEDs).

Lumen vs. current and Power

Quote

08-07-2005, 07:15 PM #9

evan9162
Flashaholic*

Join Date: Apr 2002
Location: Boise, ID
Posts: 2,138

Re: White LED lumen testing

jtr,

Sounds cool. I think I may finally do this myself someday. In another thread, I used the method, combined with the typical beam distribution from the luxeon data sheet to come up with a "Lumen coefficient". You would simply take a 0-degree lux measurement of a HD luxeon at 1m, and multiply by the coefficient to get a lumens estimate. I'm hoping to both a) verify that this coefficient is usable and b) see how well the beam distribution in the datasheet holds true.

Quote

08-07-2005, 07:38 PM #10

jtr1962
Flashaholic*

Join Date: Nov 2003
Location: Flushing, NY
Posts: 1,925

Re: White LED lumen testing

I remember that thread, Peter. It looks like you're getting a little less output than I did because the light coming out the back of the LED didn't make it to the fraen lens. Still, it looks like we're reasonably close which makes me feel better. I did a double take after I entered the data for the warden LEDs. I was saying no way can they be this good but I guess they are.

Quote

08-07-2005, 09:52 PM #11

idleprocess
Flashaholic*

Join Date: Feb 2004
Location: dfw.tx.us
Posts: 3,221

Re: White LED lumen testing

Nice!

I've often thought about doing something like that, but lack the math background (and mesurement apparatus) to do something like that.

The calculations in the LEDDB are rather lacking for accurate mcd * beam angle : lumens calculations.

I'll have to look over your spreadsheets. Most manufacturers include radiation patterns, so maybe I can borrow your work for

more accurate numbers from spec sheets...

Quote

08-08-2005, 12:52 AM #12

NewBie
Flashaholic*

Join Date: Feb 2004
Location: Oregon- United States of America
Posts: 3,985

Re: White LED lumen testing

A fella should also consider de-rating the lumens due to heat produced in real life. Especially if using as a "calibration" source.

jtr1962- Have you thought about running a luxeon at 20/40/60mA to see where they fall?

Quote

08-08-2005, 05:36 AM #13

idleprocess
Flashaholic*

Join Date: Feb 2004
Location: dfw.tx.us
Posts: 3,221

Re: White LED lumen testing

Hm. Looks like I'm going to have to take a different route - but at least I got off my butt and have a somewhat better understanding of optics.

So deviously simple-*(sounding)*!

1 lm == 1 cd / steridian

65.542173315° = 1.0000000000116693 sr *(got tired of monkeying with digits in the beam angle calulator here)*

4Pi steridians (sr) / sphere

Quote

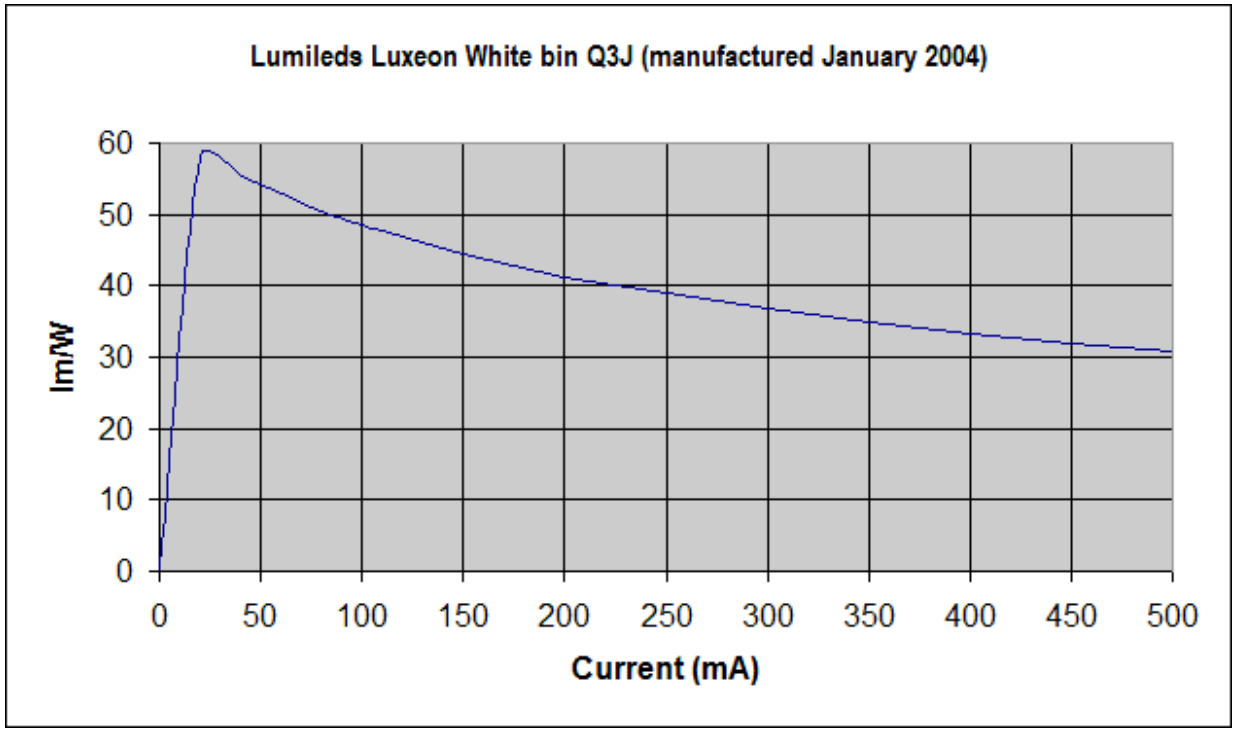
08-09-2005, 01:16 AM #14

jtr1962
Flashaholic*

Join Date: Nov 2003
Location: Flushing, NY
Posts: 1,925

Re: White LED lumen testing

I made a jig for testing power LEDs. Here are my results for a Q3J Luxeon, a Lamina BL-2000, and a Seoul Semiconductor W32182 bin RSX0I star:



08-09-2005, 07:19 AM #15

ViReN
Flashaholic*

Join Date: Apr 2004
Location: Om!
Posts: 2,164

Re: White LED lumen testing

Wow .. Amazing Data [img]/ubbthreads/images/graemlins/smile.gif[/img] Thanks for doing the test jtr1962

Any Chance you will test the Nichia NSPW500CS ... C0 / A0 Tint, U Bins...

Also, It would be interesting to see the BS LED's too...

Quote

08-09-2005, 11:09 AM #16

jtr1962
Flashaholic*

Join Date: Nov 2003
Location: Flushing, NY
Posts: 1,925

Re: White LED lumen testing

I'll probably get 5 of the Nichia CS to test from Grumpy's group buy if he has any more. Other than that I don't have any Nichias except possibly two really old ones from around 2001. I purchased them from Hosfelt Electronics but they have the tapered shape typical of Nichias. At the time they were rated at 5600 mcd, 20° viewing angle, which goes to show how old they are. Assuming a similar light distribution pattern to other 20° white LEDs I've tested so far I would imagine they would put out roughly 0.9 to 1.0 lumens at 20 mA, for an overall efficiency in the 15 lm/W area. Maybe I'll run a test on them just to verify my estimates.

If anyone wants to send me LEDs for testing PM me for my address and send a stamped, self-addressed envelope if you want the LEDs returned. For now I'm sticking to testing white LEDs. I've tested a few colored ones, but finding a true hotspot reading at 1 meter is somewhat difficult thanks to the splotchy beam patterns. Also, because of these beam patterns I'm not sure how accurate my methodology would be. Most white LEDs have a fairly even beam, making the results more valid.

Quote

08-09-2005, 06:57 PM #17

jtr1962
Flashaholic*

Join Date: Nov 2003
Location: Flushing, NY
Posts: 1,925

Re: White LED lumen testing

I added the LCK 12,000 mcd warm white, which arrived today, to my list in the first post and updated the graphs accordingly. You might need to refresh your browser to see the updated graphs.

Quote

08-12-2005, 02:27 PM #18

jtr1962
Flashaholic*

Join Date: Nov 2003
Location: Flushing, NY
Posts: 1,925

Re: White LED lumen testing

I added an old (c.2001) white LED, probably a Nichia, to the first post and updated the graphs. I also made the comparison charts easier to read by using heavier lines.

Quote

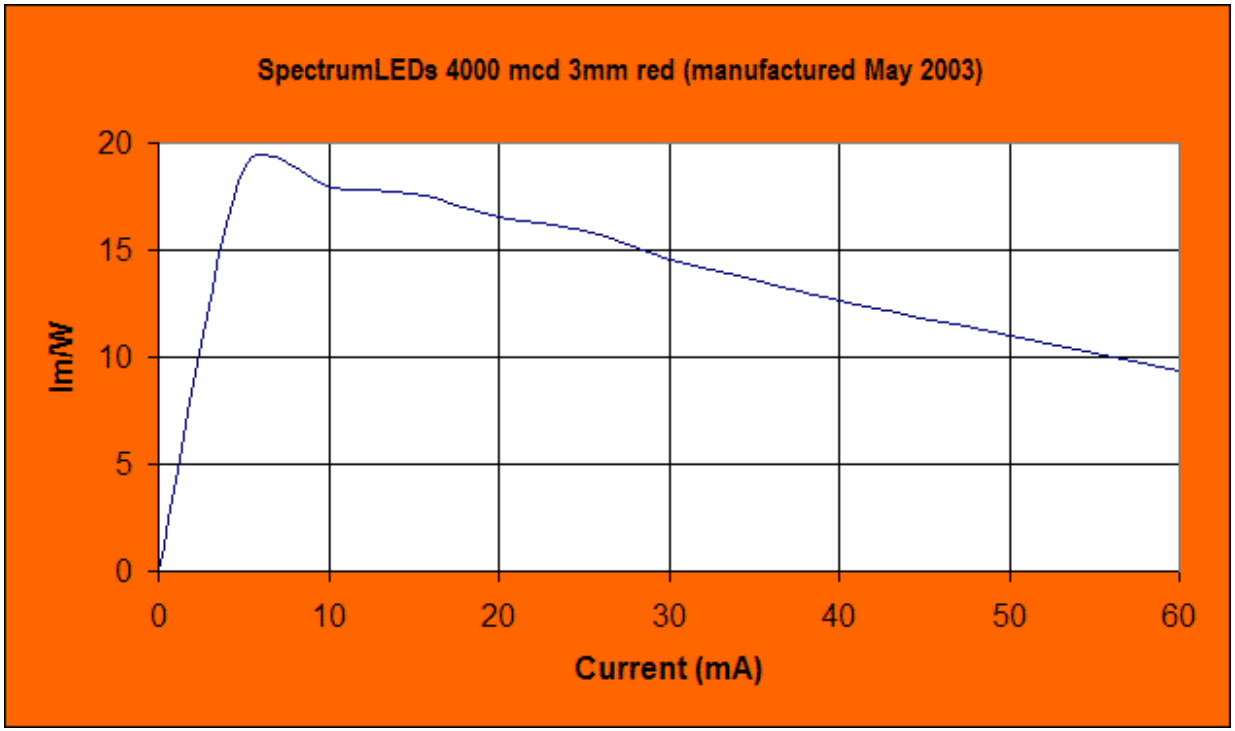
08-12-2005, 11:58 PM #19

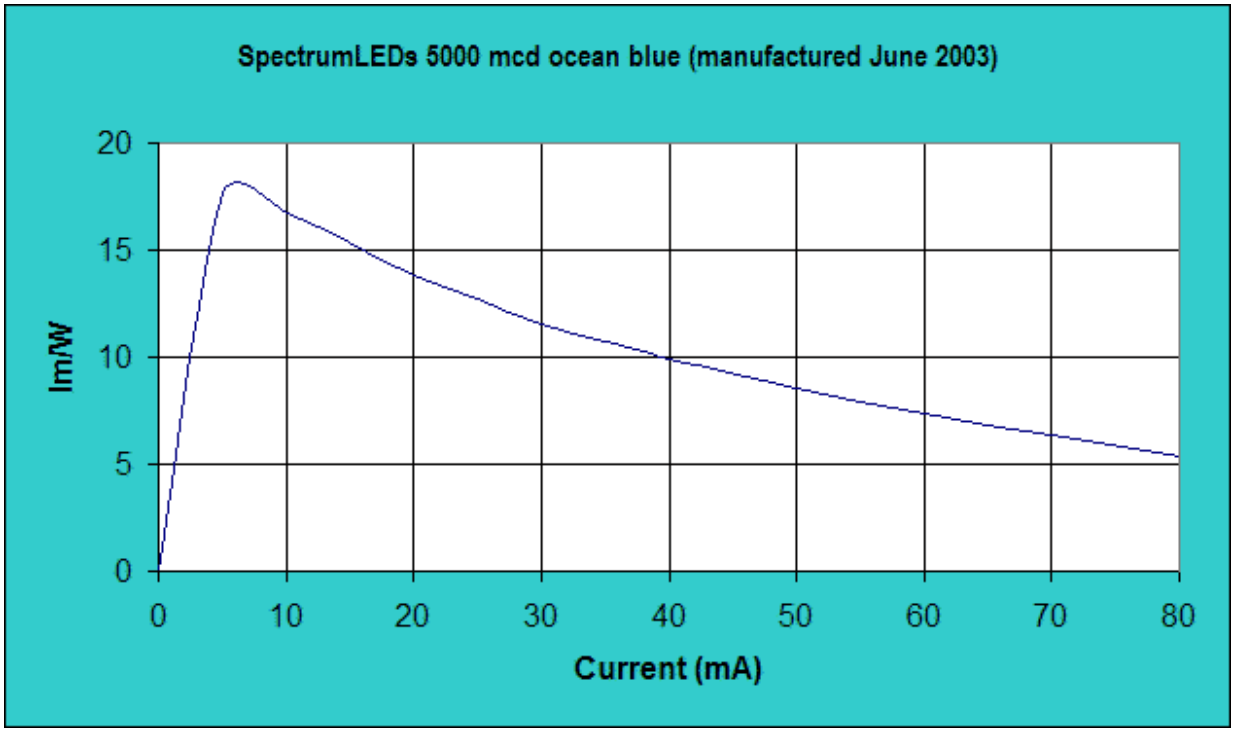
jtr1962
Flashaholic*

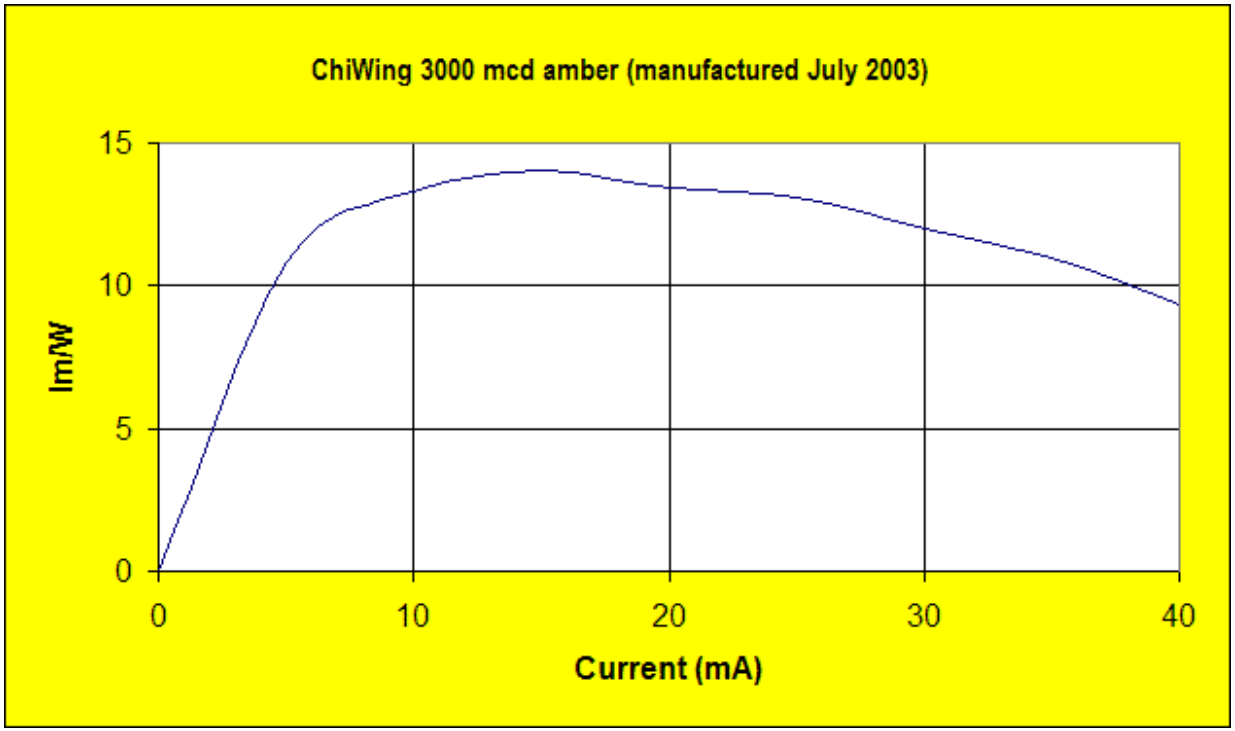
Join Date: Nov 2003
Location: Flushing, NY
Posts: 1,925

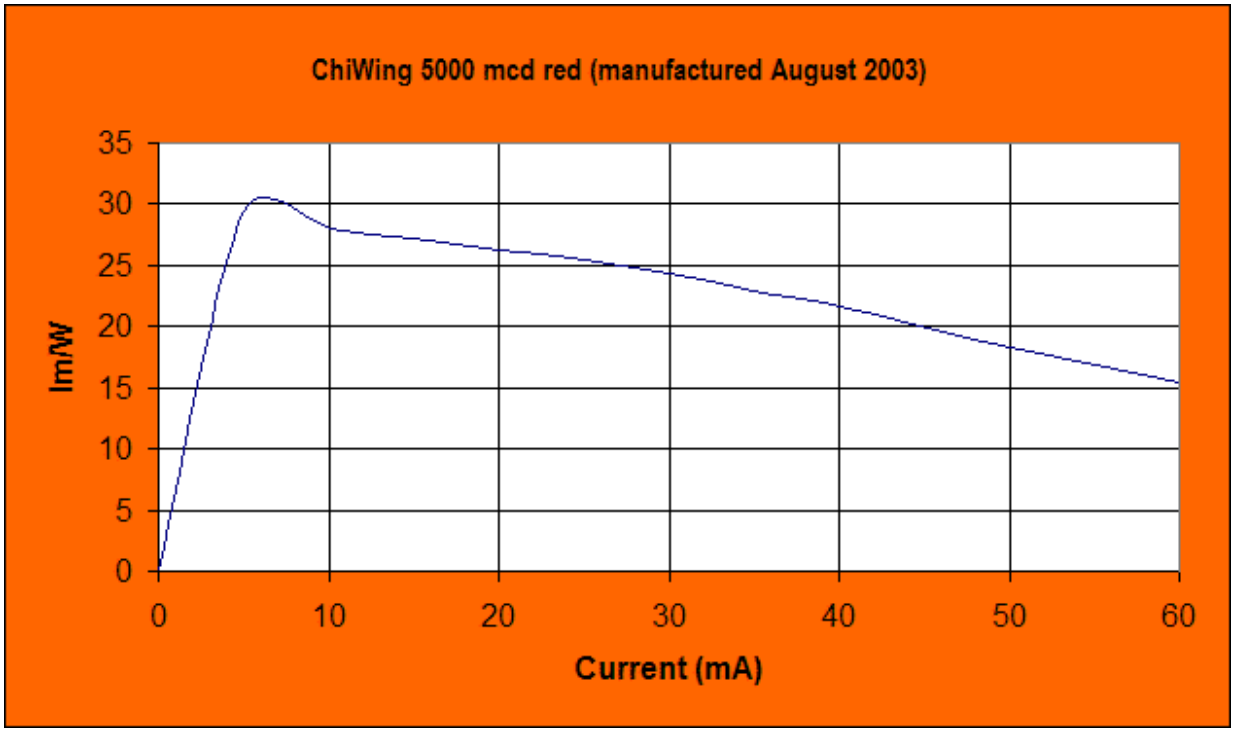
Re: White LED lumen testing

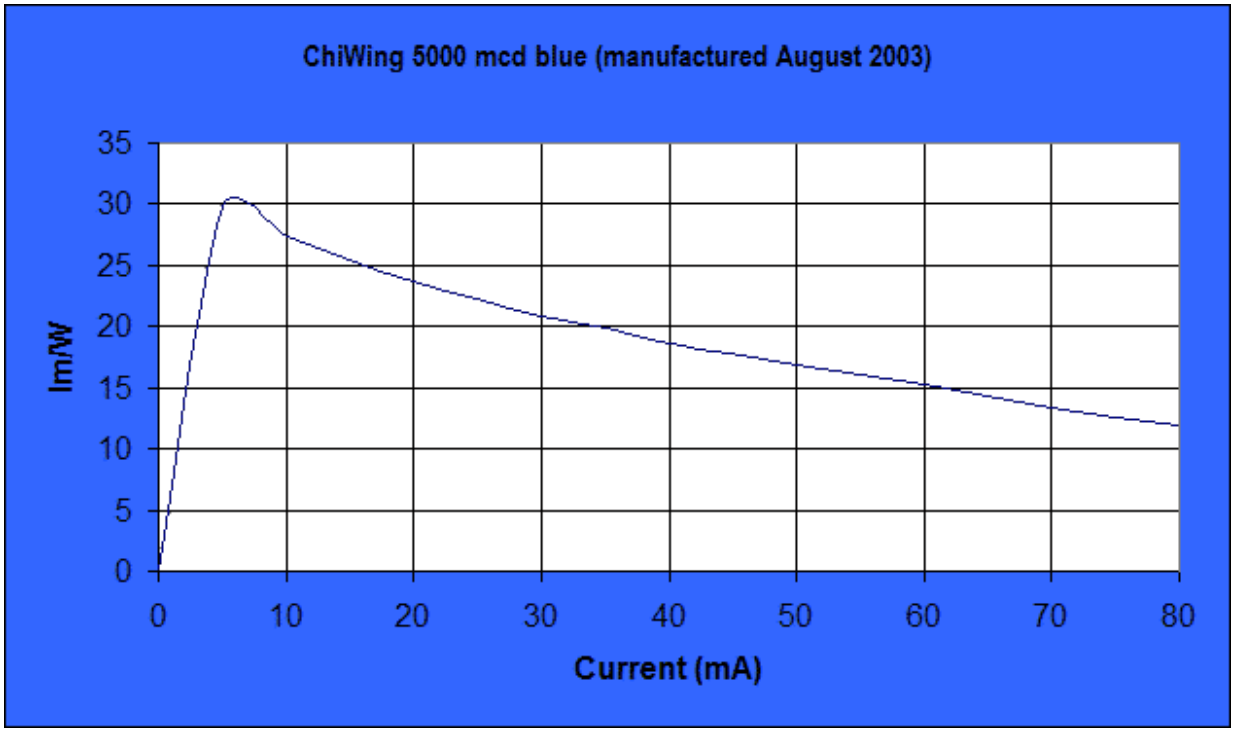
I've finished testing any colored LEDs I have worth testing (the dim indicator LEDs would be pointless). Here are the results in the order in which they were purchased:

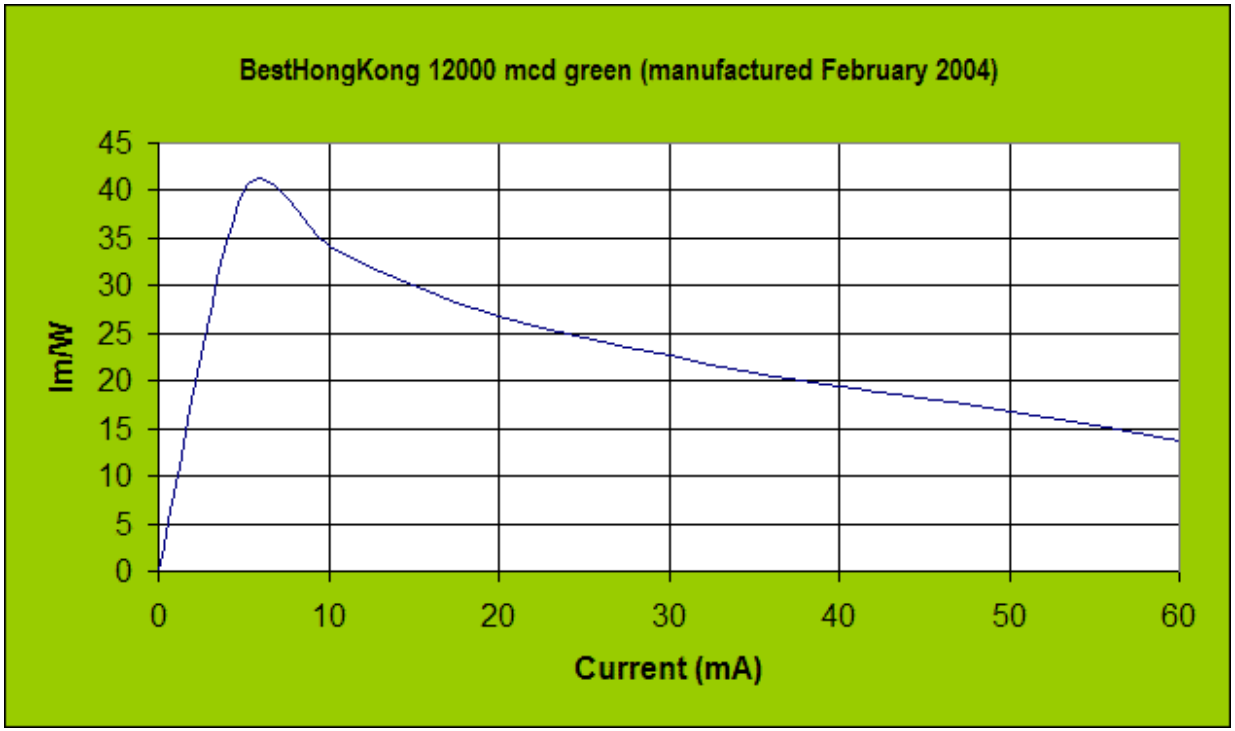

SpectrumLEDs 4000 mcd 3mm red (manufactured May 2003)
lm/W
20
15
10
5
0
0
10
20
30
40
50
60
Current (mA)

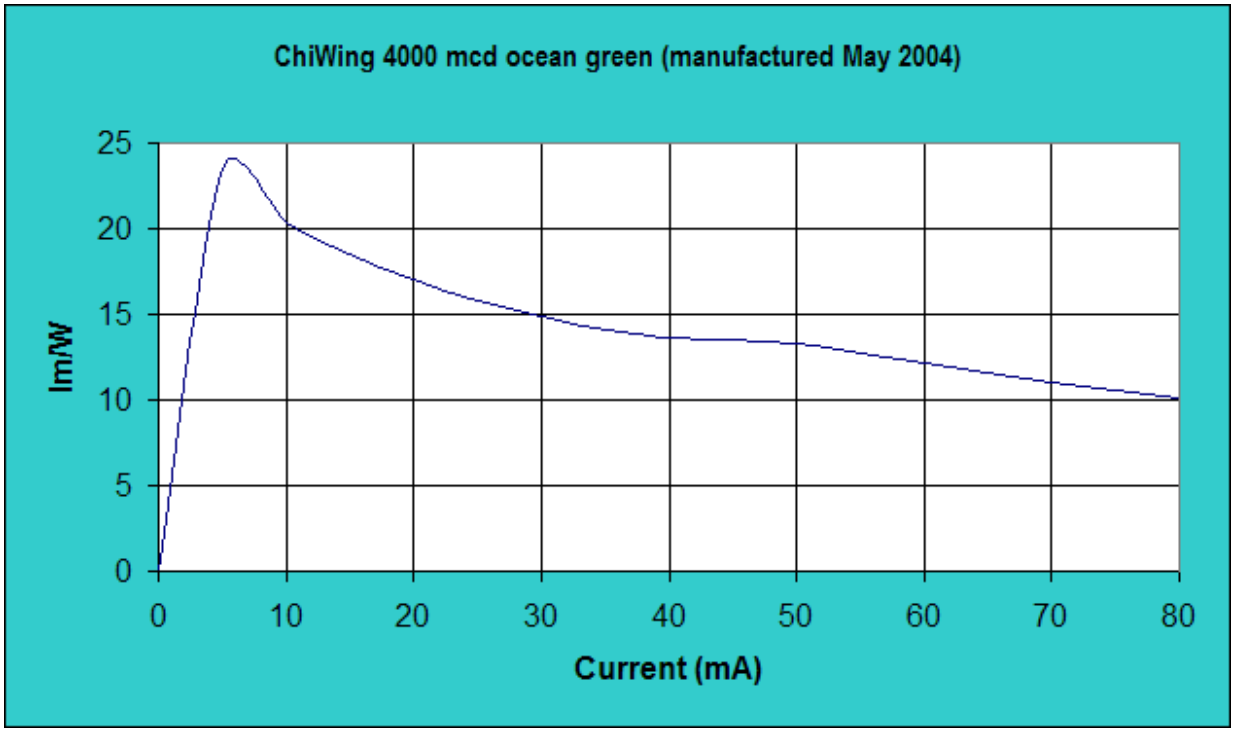

SpectrumLEDs 5000 mcd ocean blue (manufactured June 2003)
lm/W
20
15
10
5
0
0
10
20
30
40
50
60
70
80
Current (mA)

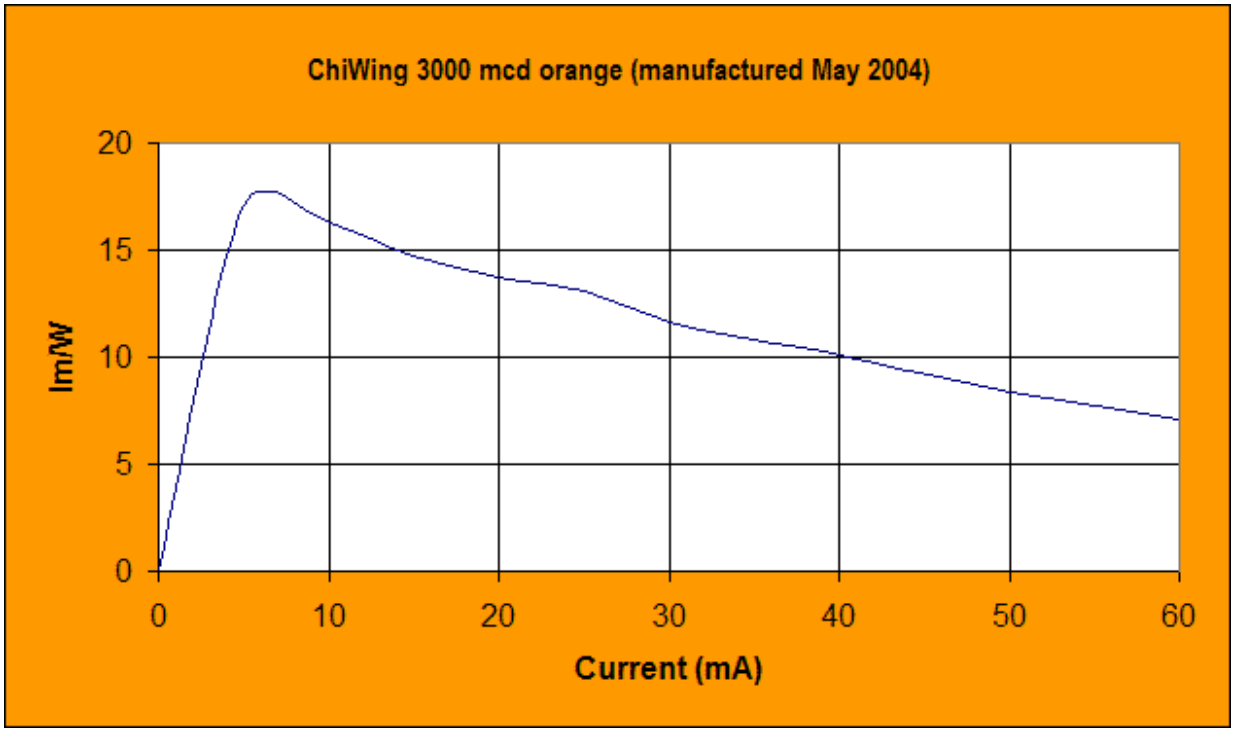

ChiWing 3000 mcd amber (manufactured July 2003)
lm/W
15
10
5
0
0
10
20
30
40
Current (mA)

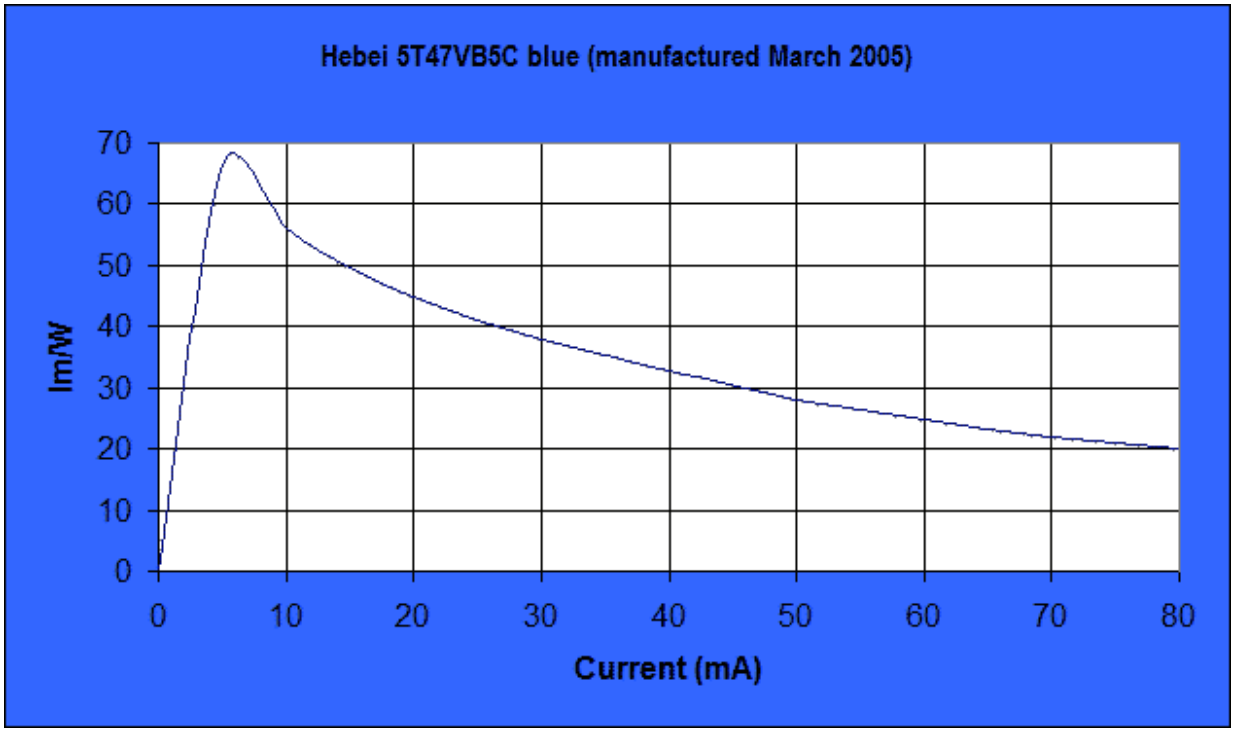

ChiWing 5000 mcd red (manufactured August 2003)
lm/W
35
30
25
20
15
10
5
0
0
10
20
30
40
50
60
Current (mA)

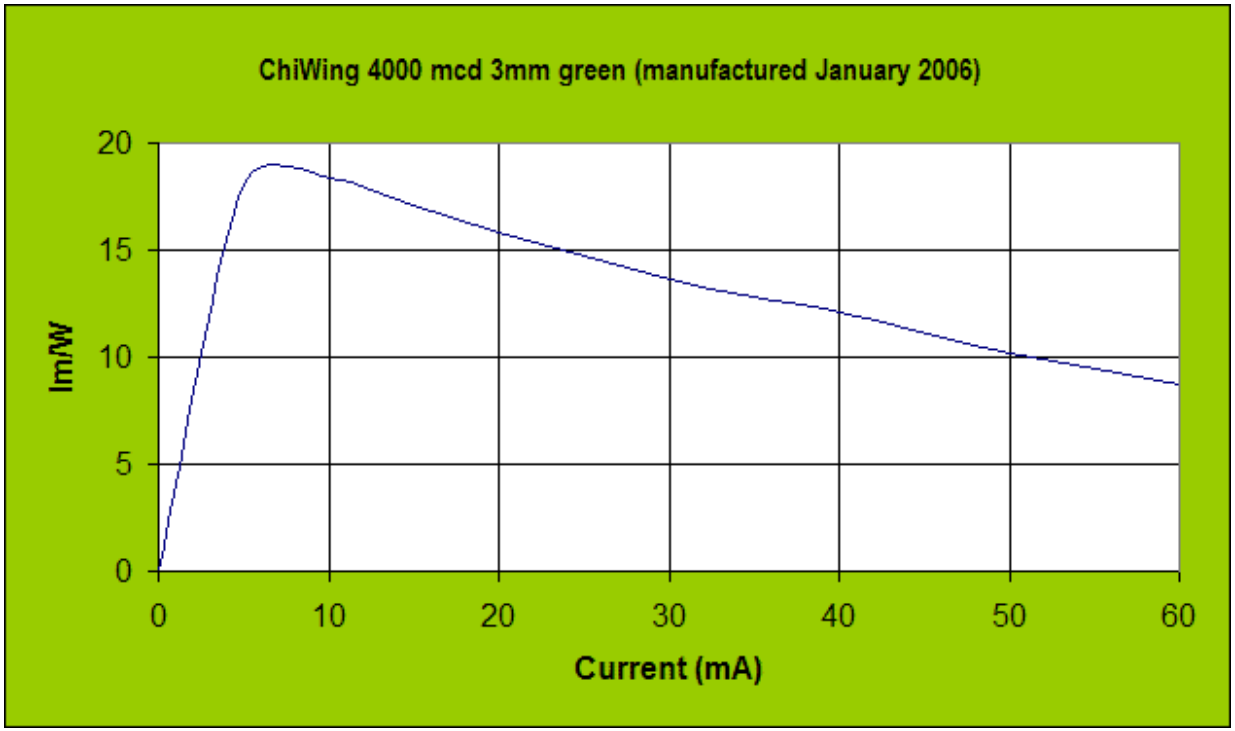

ChiWing 5000 mcd blue (manufactured August 2003)
lm/W
35
30
25
20
15
10
5
0
0
10
20
30
40
50
60
70
80
Current (mA)

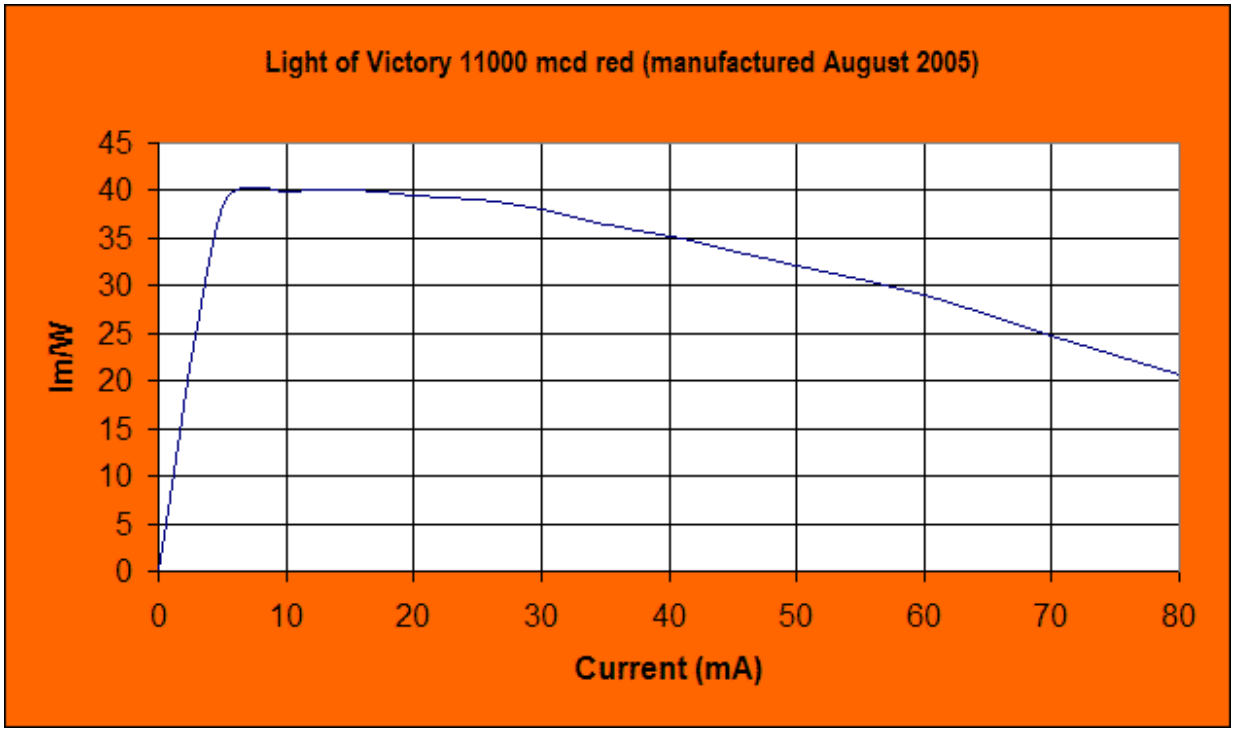

BestHongKong 12000 mcd green (manufactured February 2004)
lm/W
45
40
35
30
25
20
15
10
5
0
0
10
20
30
40
50
60
Current (mA)


ChiWing 4000 mcd ocean green (manufactured May 2004)
lm/W
25
20
15
10
5
0
0
10
20
30
40
50
60
70
80
Current (mA)


ChiWing 3000 mcd orange (manufactured May 2004)
lm/W
20
15
10
5
0
0
10
20
30
40
50
60
Current (mA)


Hebei 5T47VB5C blue (manufactured March 2005)
lm/W
70
60
50
40
30
20
10
0
0
10
20
30
40
50
60
70
80
Current (mA)


ChiWing 4000 mcd 3mm green (manufactured January 2006)
lm/W
20
15
10
5
0
0
10
20
30
40
50
60
Current (mA)



The blue LEDs are surprisingly efficient in terms of lumens per watt, especially the Hebei blue LED. The likely reason for this is that the dominant wavelength is probably somewhat higher than 470 nm. The rest of the colored LEDs fall more or less where one would expect. Except for blues and reds, colored LED efficiency has not been advancing as fast as white LED efficiency, especially for amber, orange, and yellow green.

The relevant spreadsheets were added to the .zip file linked to in the first post of this thread.

Last edited by jtr1962 : 08-05-2006 at 10:42 PM.

Quote

01-20-2006, 03:57 PM #20

jtr1962
Flashaholic*

Join Date: Nov 2003
Location: Flushing, NY
Posts: 1,925

Re: White LED lumen testing

I added the BestHongKong 40,000 mcd and Jeled 40,000 mcd to the list in the first post and updated the graphs accordingly. You might need to refresh your browser to see the updated graphs. The relevant spreadsheets were added to the .zip file linked to in the first post of this thread.

Quote

01-21-2006, 08:26 AM #21

ViReN
Flashaholic*

Join Date: Apr 2004
Location: Om!
Posts: 2,164

Re: White LED lumen testing

jtr1962 .... Great plots in deed... its valuable data when it comes to designing a light considering the Lumen/Watt & total Lumen output for a 5 mm LED

I wonder if you could help me for a project, if you have any Luxeon I (Q/R Bin's H/J Vf) and Luxeon III (S/T Bin's J/K Vf) LED's is it possible for you to have similar charts. i.e. Lumens V/S Current & Vf

i have been looking for this over the forum here and there... but could not find such a chart. i do not have the equipment to do the testing either

your help is highly appreciated.

Thanks & Regards,
ViReN

Proton - is Real!

Last edited by ViReN : 01-21-2006 at 08:30 AM.

Quote

01-21-2006, 03:23 PM #22

jtr1962
Flashaholic*

Join Date: Nov 2003
Location: Flushing, NY
Posts: 1,925

Re: White LED lumen testing

Quote:

> Originally Posted by **ViReN**
> *I wonder if you could help me for a project, if you have any Luxeon I (Q/R Bin's H/J Vf) and Luxeon III (S/T Bin's J/K Vf) LED's is it possible for you to have similar charts. i.e. Lumens V/S Current & Vf*

Hi Viren,

Thanks for the compliments, and I hope this data is useful to people. If you look a few posts up you'll see that I did indeed plot a Luxeon Q3J in the same manner as my 5mm LEDs, and included a link for the relevant spreadsheets which have the Vf versus current data. I don't have any Luxeon IIIs on hand to do plots, but I imagine they wouldn't be much different. Maybe now that Future Electronics finally lowered their prices for these to something I consider reasonable I'll pick up a few LIIIs in various colors and play around.

Quote

01-21-2006, 04:02 PM #23

winny
Flashaholic*

Join Date: Apr 2005
Location: Gothenburg, Sweden
Posts: 860

Re: White LED lumen testing

Good job jr1962!

I didn't read it all but as you used the word steradian so I'm quite confident that you know how it works. Very good. Welcome to the higher intelligence club! ;-p

From the picture it looked like you where using the same light meter as I am. I'll give you a warning on them. They are cheap and in my manual it said "the spectral response *almost* corresponds with the CIE curve". When you measure non 2860 K light sources, like LEDs, the error margin is big and comparing LEDs with different shades of white or with incans is well, questionable.

Quote

01-21-2006, 04:20 PM #24

jtr1962
Flashaholic*

Join Date: Nov 2003
Location: Flushing, NY
Posts: 1,925

Re: White LED lumen testing

Quote:

> Originally Posted by **winny**
> *From the picture it looked like you where using the same light meter as I am. I'll give you a warning on them. They are cheap and in my manual it said "the spectral response almost corresponds with the CIE curve". When you measure non 2860 K light sources, like LEDs, the error margin is big and comparing LEDs with different shades of white or with incans is well, questionable.*

The light meter is a CEM DT-1300. I took part in the light meter tests as described here. For LED-type white light my meter only seems to read a few percent above the averages of everyone elses. It does read quite high for blue LED light which explains my ridiculously high results in tests of blue LEDs (about twice as high as they should be).

Note that I did sanity check my results. The brightest 5mm LEDs nowadays are in the 60 to 70 lm/W range so if I had gotten results much different I would have been suspicious. Also, my Q bin Luxeon came in at 37 lumens, solidly in the middle of the Q bin. Again, if I had gotten results of 45 or 50 lumens, I might have been suspicious. Overall, I'd say for white LEDs my results might be about 5% or so high, if that. I'm more interested in relative measurements anyway so as to tell which LEDs are better. In the future I may adjust my data once the CPF standard LED test lights are professionally checked but for now the relative measurements are a good guide for everyone.

Quote

01-21-2006, 04:30 PM #25

winny
Flashaholic*

Join Date: Apr 2005
Location: Gothenburg, Sweden
Posts: 860

Re: White LED lumen testing

You obviously have thought of everything! Very good.

I hope I didn't offend you, but I just had to warn you as my light meter can be waaay of when it comes to LEDs sometimes. I'll send mine to SilverFox for testing when he get the lamps back.

Anyway, how much did you get out of that MR16 in the background of the picture?

Last edited by winny : 01-21-2006 at 04:33 PM. Reason: added a question

Quote

01-21-2006, 04:37 PM #26

jtr1962
Flashaholic*

Join Date: Nov 2003
Location: Flushing, NY
Posts: 1,925

Re: White LED lumen testing

Quote:

> Originally Posted by **winny**
> *Anyway, how much did you get out of that MR16 in the background of the picture?*

I never tested it but now that you mentioned it I think I will. BTW, it's a standard 50W halogen MR-16 so I figure it should be good for ~1000 lumens.

Quote

02-01-2006, 10:53 AM #27

jtr1962
Flashaholic*

Join Date: Nov 2003
Location: Flushing, NY
Posts: 1,925

Re: White LED lumen testing

I added the Jeled 50,000 mcd to the list in the first post and updated the graphs accordingly. You might need to refresh your browser to see the updated graphs. The relevant spreadsheets were added to the .zip file linked to in the first post of this thread.

Quote

02-01-2006, 12:26 PM #28

winny
Flashaholic*

Join Date: Apr 2005
Location: Gothenburg, Sweden
Posts: 860

Re: White LED lumen testing

Any progress on the MR16?

Quote

02-01-2006, 05:14 PM #29

jtr1962
Flashaholic*

Join Date: Nov 2003
Location: Flushing, NY
Posts: 1,925

Re: White LED lumen testing

Quote:

> Originally Posted by **winny**
> *Any progress on the MR16?*

Unfortunately, that picture was taken before I cleaned the room and now I can't remember where I put the MR16. If/when it turns up I'll be sure to test it and post the results. I did actually look for it for a while when you first mentioned testing it but had no luck.

Quote

02-02-2006, 06:12 AM #30

Pinter
Enlightened

Join Date: Oct 2003
Location: Hungary, Europe
Posts: 89

Re: White LED lumen testing

Quote:

> Originally Posted by **jtr1962**
> *For LED-type white light my meter only seems to read a few percent above the averages of everyone elses. It does read quite high for blue LED light which explains my ridiculously high results in tests of blue LEDs (about twice as high as they should be).*

That means that leds with blue hotspot are resulting in higher Lux reading in your test than real white ones?

Quote

02-02-2006, 07:01 AM #31

hotbeam
Flashaholic*

Join Date: Jan 2003
Location: Melb, AU
Posts: 1,984

Re: White LED lumen testing

jtr, fantastic set of results. you must be a very persistent fellow

Hotlips Heatsinks for OAC/Ds | MR-X | X3T | PocketMate-W

Quote

02-03-2006, 12:33 AM #32

jtr1962
Flashaholic*

Join Date: Nov 2003
Location: Flushing, NY
Posts: 1,925

Re: White LED lumen testing

Quote:

> Originally Posted by **Pinter**
> *That means that leds with blue hotspot are resulting in higher Lux reading in your test than real white ones?*

Maybe except that the greatest errors with my meter occur with narrowband blue light such as from a blue LED, rather than the bluish-white hotspots present in some white LEDs. As a reality check on the accuracy of my light meter I compare my intensity results to ratings. If anything, most eBay sellers overrate their LEDs so I should be getting lower intensities. In fact, that is almost always the case. Only a few sellers, such as BestHongKong and ChiWing, usually live up to their ratings, or occasionally even exceed them. The only time I get intensity readings well above ratings across many manufacturers is with blue LEDs. The CPF light meter test verified that my meter is indeed reading very high for blue light but pretty much on the mark for white light (both incandescent and LED).

Quote

02-03-2006, 12:34 AM #33

jtr1962
Flashaholic*

Join Date: Nov 2003
Location: Flushing, NY
Posts: 1,925

Re: White LED lumen testing

Quote:

> Originally Posted by **hotbeam**
> *jtr, fantastic set of results. you must be a very persistent fellow*

Obsessive-compulsive is sometimes a better description of me.

Quote

03-04-2006, 03:30 PM #34

vortechs

CPF Silver Supporter

Join Date: Feb 2006
Location: Phoenix, AZ
Posts: 969

Re: White LED lumen testing

Hi jtr1962,

I was really happy to find this thread reviewing the 50k white LED's from jeled. Thanks for all your work to compare the real statistics and output from all of these different LED types.

Are you still running new tests on white LED's and, if so, what LED's are you planning to test next?

I've been thinking about getting the 3mm white 18,000mcd LED's available from jeledhk on eBay (link). Their published stats show 15,000 to 18,000mcd with a 30 degree viewing angle, but I'm wondering how close to this they actually are. I've been considering getting some to modify one of KevinL's picolights that use 3mm LED's and possibly for a solitare or 2AA maglite mod without needing the reflector modification that using a 5mm LED would require.

If you've already tested these 18k 3mm white LED's or are planning to test them, please let me know. Alternatively, if you are interested, I could get some and send you a few to test (I don't know what I'd do with 50 of them anyway).

Quote

03-10-2006, 08:15 PM #35

jtr1962
Flashaholic*

Join Date: Nov 2003
Location: Flushing, NY
Posts: 1,925

Re: White LED lumen testing

Quote:

> Originally Posted by **vortechs**
> *Are you still running new tests on white LED's and, if so, what LED's are you planning to test next?*

These tests are ongoing, and I just updated the first post with the Peak Snow 29 and Nichia CS B1U LEDs sent to me by CPF member Pinter. I'm accepting LEDs for testing, and also will continue testing any new ones I acquire for my own personal use.

Quote:

> If you've already tested these 18k 3mm white LED's or are planning to test them, please let me know. Alternatively, if you are interested, I could get some and send you a few to test (I don't know what I'd do with 50 of them anyway).

If you've gotten the 18K 3mm LEDs and have some left I'll be happy to test them. Just PM me for a mailing address.

Quote

03-10-2006, 08:20 PM #36

jtr1962
Flashaholic*

Join Date: Nov 2003
Location: Flushing, NY
Posts: 1,925

Re: White LED lumen testing

I also tested the Seoul Semiconductor W32182 1 watt stars. The results are in this post. Interestingly, I got an luminous flux of almost exactly the 52 lumens claimed as typical at 350 mA for this part.

Quote

03-10-2006, 08:24 PM #37

winny
Flashaholic*

Join Date: Apr 2005
Location: Gothenburg, Sweden
Posts: 860

Re: White LED lumen testing

Have you found that MR16 yet?

Need regulation? Programmable Incandescent Regulator 1
Featuaring user settable softstart, low voltage cutout, three voltage settings and warning level. USB-connectable.
7-30 V input, 0-Uin output, >97% efficient. 0-500 W - no problem

Quote

03-10-2006, 08:27 PM #38

jtr1962
Flashaholic*

Join Date: Nov 2003
Location: Flushing, NY
Posts: 1,925

Re: White LED lumen testing

Quote:

> Originally Posted by **winny**
> *Have you found that MR16 yet?*

Not yet, but I think I have a good idea where I put it. Stay tuned....

Quote

03-14-2006, 03:01 AM #39

Pinter
Enlightened

Join Date: Oct 2003
Location: Hungary, Europe
Posts: 89

Re: White LED lumen testing

Hi jtr1962,

Thank you for testing the Nichias and Peak Snow, I did not think you measure all 9 samples.
Nichia performance was a real surprise over 60mA. This is in good correlation with another thread in which Nichia has shown better lumen maintenance at 60mA than others at 30mA.

I have some questions about the methodology:
- what is the sensor diameter
- (whether if I understood correctly) you measure the beam profile from 17.5" then you read the peak lux readings from 1m on different currents and weight this data with the relative intensity that came from the profile?

Quote

03-14-2006, 04:26 AM #40

jtr1962
Flashaholic*

Join Date: Nov 2003
Location: Flushing, NY
Posts: 1,925

Re: White LED lumen testing

Quote:

> Originally Posted by **Pinter**
> *I have some questions about the methodology:*
> *- what is the sensor diameter*
> *- (whether if I understood correctly) you measure the beam profile from 17.5" then you read the peak lux readings from 1m on different currents and weight this data with the relative intensity that came from the profile?*

Sensor diameter is 1.5". I chose 17.5" as the measuring distance because the sensor diameter at that distance covers exactly 5° of the beam, and I measure output in 5° increments. When I'm done I weight the beam profile data with my lux readings from exactly one meter, and use a spreadsheet to do the calculations. The end result is of course the total output in lumens. Yes, I do all the lux readings at different currents at one meter, although since they're all relative anyway I could just as easily do them at 17.5", and only do the 1 meter lux reading at one current just to weight all my data. The method works surprising well. The main source of error seems to be the absolute value of my lux readings at 1 meter. The meter is supposed to be within 10%, so I assume this is the upper bounds of my error. In practice, based on my relative measurements in Silverfox's light meter benchmark testing, my light meter is reading maybe 5% high for white LED type light compared to the average (although the average isn't necessarily dead accurate).

In any case, my results aren't horribly off. The U bin Nichias are supposed to be in the vicinity of 60 lm/W efficiency at 20 mA but Vf is typically about 3.4 volts. The samples you sent me had a lower Vf in the 3.2V area which would put efficiency into the mid 60s. Furthermore, all seemed to be at the upper end of the U bin, probably pushing them into the 70 to 75 lm/W area. Since 75 lm/W is what I measured, my errors are likely 5% or less. This also explains why V bin Nichias are very rare. They need to have efficiencies of 80 lm/W or higher, and this represents the present upper limit of production white LEDs these days.

Quote

04-22-2006, 01:07 PM #41

NewBie
Flashaholic*

Join Date: Feb 2004
Location: Oregon- United States of America
Posts: 3,985

Re: White LED lumen testing

Quote:

> Originally Posted by **jtr1962**
> *The meter is supposed to be within 10%, so I assume this is the upper bounds of my error. In practice, based on my relative measurements in Silverfox's light meter benchmark testing, my light meter is reading maybe 5% high for white LED type light compared to the average (although the average isn't necessarily dead accurate).*

Unfortuately, the majority of the error is in the spectral response. These meters are "calibrated" for incandescent, sodium vapor, fluorescent, and such. Some have correction tables built in you select the type of light source, to adjust for the error, others have the correction factor in the manual that you have to apply manually. Read your manual, if it worth beans at all, they will mention those correction factors (the LM631 is only accurate for tungsten lamps as I recall).

An example is one of the higher end, unfortunately more expensive light meter (though it is not accurate for LEDs):
http://www.extech.com/instrument/pr...nualregist.html

Unfortunately, nobody I know of has created a spectral correction factor for white LEDs, and that would be somewhat futile, since the white led spectrum varies from white LED to white LED, even from the same manufacturer.

One of the few instruments that can remove this *very* significant source of error is a spectroradiometer, and they are darned expensive.

_____

I exist, therefor I am!
a.k.a. Jarhead

DC Stats

Last edited by NewBie : 04-22-2006 at 01:26 PM.

Quote

06-18-2006, 03:37 AM #42

NewBie
Flashaholic*

Join Date: Feb 2004
Location: Oregon- United States of America
Posts: 3,985

Re: White LED lumen testing

Results of the certified testing of a batch of lights, as compared to various folks light meters can be found here:
http://candlepowerforums.com/vb/sho...4&postcount=461

Note the large error, especially for the Red Green and Blue.

Hopefully, some day, someone will have a chance to test "white" LEDs from several bins the same way, vs. light meter reported results.

I exist, therefor I am!
a.k.a. Jarhead

DC Stats

Quote

06-26-2006, 02:04 AM #43

LumenHound
Flashaholic*

Join Date: Apr 2005
Location: Toronto
Posts: 885

Re: White LED lumen testing

Newbie, I would like to know how these leds would test out on your light meter using the identical testing procedure jtr1962 used.

Jeled 40K, 50K
BestHongKong 40K
Light of Victory 35K
Peak Snow 29
Nichia CS B1U white

I think it would be very interesting and informative to see what variations there are from one consumer level light meter to the next.

Anxiously awaiting your results...

Quote

06-26-2006, 02:20 AM #44

NewBie
Flashaholic*

Join Date: Feb 2004
Location: Oregon- United States of America
Posts: 3,985

Re: White LED lumen testing

Quote:

> Originally Posted by **LumenHound**
> *Newbie, I would like to know how these leds would test out on your light meter using the identical testing procedure jtr1962 used.*
>
> *Jeled 40K, 50K*
> *BestHongKong 40K*
> *Light of Victory 35K*
> *Peak Snow 29*
> *Nichia CS B1U white*
>
> *I think it would be very interesting and informative to see what variations there are from one consumer level light meter to the next.*
>
> *Anxiously awaiting your results...*

Variation testing has been done, along with Certified Lab Testing, see this thread:
http://candlepowerforums.com/vb/sho...d.php?p=1461977

_____
I exist, therefor I am!
a.k.a. Jarhead

DC Stats

Quote

06-26-2006, 02:44 AM #45

LumenHound
Flashaholic*

Join Date: Apr 2005
Location: Toronto
Posts: 885

Re: White LED lumen testing

Excellent thread. Thanks for the link.
Looks like I'm going to need to get a fresh cup of coffee before I get comfortable and start to wade through it all.

Quote

06-26-2006, 02:42 PM #46

jtr1962
Flashaholic*

Join Date: Nov 2003
Location: Flushing, NY
Posts: 1,925

Re: White LED lumen testing

I haven't been keeping up much on things around here since my father died on March 28 but this thread being bumped caught my attention. Three or so months ago Pinter analyzed my testing procedure and found that in theory my reported results would be higher than the actual results due to my using 5° increments instead of smaller ones. The difference between actual and reported would be higher for narrower beam LEDs than for wide-beam ones, but for most 15° to 20° LEDs it was on the order of 10%. By sheer coincidence my light meter reads about 10% low compared to the lab standard so the errors more or less cancel. Of course, the spectra of the white LEDs I test is different from the spectra of A1 white but nevertheless it gives some idea of the typical errors of my meter when measuring white LEDs. Anyway, while I certainly won't say my lumen measurements are dead accurate, I think it's reasonable to say they're within 10%. As for the color LED measurements, after seeing how much my meter is off, and also how a slight shift in center wavelength can make any "corrections" based on the standard meaningless, I've decided to refrain from testing any more colored LEDs. The results, other than for relative light intensity versus beam angle, are utterly worthless since I don't possess the equipment to

accurately measure the spectral distribution.

I plan to eventually add to this thread but for now there don't seem to be any new white LEDs worth testing and I'm still grieving over my father. Perhaps when the 85 lm/W and 100 lm/W Nichias are in circulation later this year I'll continue. I'd also love to test one of Cree's new 131 lm/W LEDs as it represents a good 50% increase over my best efficiency measures so far.

Quote

06-26-2006, 02:46 PM #47

jtr1962
Flashaholic*

Join Date: Nov 2003
Location: Flushing, NY
Posts: 1,925

Re: White LED lumen testing

Quote:

> Originally Posted by **NewBie**
> *Unfortunately, nobody I know of has created a spectral correction factor for white LEDs, and that would be somewhat futile, since the white led spectrum varies from white LED to white LED, even from the same manufacturer.*

True, but in much the same way corrections for fluorescent sources are somewhat futile as well. While many light meters may have a correction for old-school halophosphor cool-whites there are so many types and color temps of fluorescents available now which differ markedly in their spectra from the "standard" fluorescent used in the corrections.

Quote

07-17-2006, 11:59 AM #48

milkyspit
Flashaholic*

Join Date: Sep 2002
Location: New Jersey
Posts: 3,024

Re: White LED lumen testing

Jtr, you rule!!! This is some GREAT information. Certainly is a Godsend for me!

BTW, check your PM Inbox... PM sent!

--Scott


Milkyspit: Be Very Afraid.


MC2 order NOW!


C2 McR27L UXOJ.


Milky's Project-M.


For Sale or Trade.


Old Threads Index.

Edit Quote

07-17-2006, 04:46 PM #49

jtr1962
Flashaholic*

Join Date: Nov 2003
Location: Flushing, NY
Posts: 1,925

Re: White LED lumen testing

Quote:

> Originally Posted by **milkyspit**
> *Jtr, you rule!!! This is some GREAT information. Certainly is a Godsend for me!*
>
> *BTW, check your PM Inbox... PM sent!*

PM read and answered.

Thanks for the praise! I'm certainly glad many are finding this info useful. Now if I could only get my hands on some of those 131 lm/W Crees soon for some testing...

Quote

07-17-2006, 08:28 PM #50

Xe54
Enlightened

Join Date: Sep 2005
Posts: 65

Re: White LED lumen testing

Quote:

> Originally Posted by **NewBie**
> *Unfortuately, the majority of the error is in the spectral response. These meters are "calibrated" for incandescent, sodium vapor, fluorescent, and such. Some have correction tables built in you select the type of light source, to adjust for the error, others have the correction factor in the manual that you have to apply manually. Read your manual, if it worth beans at all, they will mention those correction factors (the LM631 is only accurate for tungsten lamps as I recall).*
>
> *An example is one of the higher end, unfortunately more expensive light meter (though it is not accurate for LEDs): http://www.extech.com/instrument/pr...nualregist.html*
>
> *Unfortunately, nobody I know of has created a spectral correction factor for white LEDs, and that would be somewhat futile, since the white led spectrum varies from white LED to white LED, even from the same manufacturer.*
>
> *One of the few instruments that can remove this *very* significant source of error is a spectroradiometer, and they are darned expensive.*

Theoretically speaking, IF a highly accurate photopic filter could be achieved to cause a transducer such as a photodiode to be accurately matched in response to the human eye (according to the current standard response curve) then that detector would exhibit accurate lux measurements for any color temperature of white light and even for monochromatic sources.

I believe I have found the most accurate photopic photodiodes available in the marketplace. One is the OSI Optoelectronics (used to be UDT Sensors) PIN10AP device in the datasheet below:

http://www.osioptoelectronics.com/p...omb_OSIOpto.pdf

Note however that the $275 device (with 6 month lead time) is specified as having 4% max error in area vs. CIE rather than error at any particular wavelength. Unfortunately the error at some specific wavelengths in the 470-520nm region is very large. This still precludes the use of the device for highly accurate photometric measurements of monochromatic sources near the blue, and perhaps could lead to significant errors even with white LEDs with a large blue spectral peak. I do expect however that a device such as this is considerably more accurate than a typical lux meter sensor.

When searching for this device, I found devices from two other manufacturers. A Hamamatsu device in BNC package was ridiculously expensive, more than $1000, though I think around $60 but unobtanium in small quantity for the TO-5 package.

http://sales.hamamatsu.com/assets/p...9219_series.pdf

The other device was from Advanced Photonix, PDV-C406, but which is no longer shown on their website (I have a datasheet and 4 samples if anyone's interested). Actually was from a company they recently acquired, though they told me in an email that the product would still be available. They also said the response was never calibrated.

http://www.advancedphotonix.com/index.asp

Hmm, now I need to consider whether to cancel my backordered PIN10/AP device...

_____
_____
Good day!

Quote

07-25-2006, 09:13 PM #51

jtr1962
Flashaholic*

Join Date: Nov 2003
Location: Flushing, NY
Posts: 1,925

Re: White LED lumen testing

I added four samples (MPJA 15,000mcd 10mm, unknown 26,000 mcd, LS Diodes THC3, SMJLED) sent to me by CPF member milkyspit to the list in the first post and updated the graphs accordingly. You might need to refresh your browser to see the updated graphs. The relevant spreadsheets were added to the .zip file linked to in the first post of this thread.

Quote

08-05-2006, 05:25 AM #52

jtr1962
Flashaholic*

Join Date: Nov 2003
Location: Flushing, NY
Posts: 1,925

Re: White LED lumen testing

I added the Nichia NSPW310BS wide angle 3mm white LED to the list. You might need to refresh your browser to see the updated graphs. The relevant spreadsheets were added to the .zip file linked to in the first post of this thread.

Quote

08-05-2006, 09:36 AM #53

milkyspit
Flashaholic*

Join Date: Sep 2002
Location: New Jersey
Posts: 3,024

Re: White LED lumen testing

Jtr, this is admittedly a VERY picky little request... but if it's not overly difficult, could you post your charts as separate images rather than a single big, long, continuous image? I love your research and like to save a copy of this thread locally for quick reference purposes... even turn it into a PDF for convenience... but those ultra-long images are giving me fits! No matter what I do, they get cutoff at page bottom. (As in a physical page... piece of paper.) I would need to cut them apart by hand in Photoshop then recreate a hacked version of the thread to fix the problem... if you can generate them as separate images to begin with, it would be a BIG help!

--Scott


Milkyspit: Be Very Afraid.


MC2 order NOW!


C2 McR27L UXOJ.


Milky's Project-M.


For Sale or Trade.


Old Threads Index.

Edit Quote

08-05-2006, 12:48 PM #54

SemiMan
Enlightened

Join Date: Jan 2005
Posts: 97

Re: White LED lumen testing

GREAT TEST!

"It's interesting that for narrow viewing angle (i.e. 15° or 20°) LEDs the traditional methods of calculating lumens in the main beam grossly underestimates the output. One can see why by examining the radiation pattern of one of these LEDs. Some light falls outside the main beam but this decreases in intensity rather quickly."

When reading your post, I got the impression that you used different distances depending on the LED? If true, this would effect your measurements somewhat.

If possible, it is best to place the LED as far from the meter as possible given the resolution of the meter. This ensures the most homogenous output on the light meter. At those short distances the cosine correction may come into play assume the meter is corrected.

Interesting that your blue output is higher than normal. Most low cost light meters (i.e. less than $2,000) are very inaccurate at the wavelength of blue LEDs used for white LEDs often reading 50% low or more. This changes rapidly around that spot as well making things worse. This can effect the measurements by about 10-15% overall (low), but not the end of the world.

Overall, great experiment and nice set setup.

One way to improve things would be to put a length of 2" PVC pipe painted inside with a very flat black paint in front of your light meter. This will get rid of a lot of the side reflections from the LED hitting other things plus general ambient light.You may need to be careful with this given how close your LED is though.

Quote

08-05-2006, 04:15 PM #55

jtr1962
Flashaholic*

Join Date: Nov 2003
Location: Flushing, NY
Posts: 1,925

Re: White LED lumen testing

Quote:

> Originally Posted by **milkyspit**
> *Jtr, this is admittedly a VERY picky little request... but if it's not overly difficult, could you post your charts as separate images rather than a single big, long, continuous image? I love your research and like to save a copy of this thread locally for quick reference purposes... even turn it into a PDF for convenience... but those ultra-long images are giving me fits! No matter what I do, they get cutoff at page bottom. (As in a physical page... piece of paper.) I would need to cut them apart by hand in Photoshop then recreate a hacked version of the thread to fix the problem... if you can generate them as separate images to begin with, it would be a BIG help!*

I'm actually thinking of doing that because that long image is getting unwieldy. I simply have to see how much web space

separate images versus one large one would take up as Roadrunner only gives me 5 MB of web space. It would make my life easier in that I wouldn't have to edit that huge picture every time I test a new LED.

Quote

08-05-2006, 04:50 PM #56

jtr1962
Flashaholic*

Join Date: Nov 2003
Location: Flushing, NY
Posts: 1,925

Re: White LED lumen testing

Quote:

> Originally Posted by **SemiMan**
> *When reading your post, I got the impression that you used different distances depending on the LED? If true, this would effect your measurements somewhat.*

When doing the beam profile the LED is 17.5" inches from the light meter in all cases. My test apparatus sees to that. This is the distance at which one 5° increment is the same size as the diameter of my light meter sensor. Another reason for using the shorter distance to measure the beam profile is that the background light represents a smaller percentage of my reading. As I mentioned it's at most 0.3 lux with the brighter LEDs. If I took the beam profile at 1 meter instead then once I got off center axis my readings might differ from the background reading by less than 0.1 lux, which is the resolution of my light meter. If I had a light meter with an extra digit then I might be able to do this but 4.5 digit light meters seem very rare and expensive. Of course, I do measure the actual intensity in mcd of the LED at 1 meter. One interesting thing to note is that since my background readings are limited in resolution to 0.1 lux increments then the final lumen values technically have a granularity of roughly $(17.5/39.3)^2 \times 0.1 \times 4\pi$ or 0.25 lumens. This is generally way less than 10% of the total lumen output at 20 mA of most LEDs these days. Doing the beam profile at a higher test current than this would reduce the contibution of the finite meter resolution to the final calculation.

Quote:

> Interesting that your blue output is higher than normal. Most low cost light meters (i.e. less than $2,000) are very inaccurate at the wavelength of blue LEDs used for white LEDs often reading 50% low or more. This changes rapidly around that spot as well making things worse. This can effect the measurements by about 10-15% overall (low), but not the end of the world.

Yes, for colored and especially blue LEDs my readings are way off which is why I decided to refrain from further testing of

colored LEDs. While the blue component can undoubtedly affect the reading from white LEDs somewhat, I have yet to find any white LED which gives significantly more than its rated mcd (with the exception of the MPJA 10 mm). In fact, most of the eBay LEDs I've tested thus far read *under* their rated mcd. The Nichias seem to be very close to what they're supposed to be so I suppose that tells me my light meter isn't terribly off.

Another sanity check are the tests done for wide angle power LEDs like Luxeons. Q-bin Luxeons test right in the mid-range of the Q bin. A Seoul Semiconductor LED tested right at the 52 lumen typical value shown in the data sheet. Wide angle LEDs are less prone to the sorts of errors which might affect more narrow beam LEDs. It might be interesting to one day check how some of my tested LEDs do in a calibrated integrating sphere. My guess is they probably wouldn't be more that 10% to 15% off except possibly in the case of 10 mm LEDs with very narrow beams.

Quote:

> One way to improve things would be to put a length of 2" PVC pipe painted inside with a very flat black paint in front of your light meter. This will get rid of a lot of the side reflections from the LED hitting other things plus general ambient light.You may need to be careful with this given how close your LED is though.

I may one day build a new test apparatus with some of these improvements, including detents on the angle wheel to make the testing yet more consistent. I do place the apparatus on top of a narrow cardboard box now so as to minimize the stray reflections. I plan to paint the top of the box and the rest of my apparatus flat black. One thing to note is that the stray reflections mainly make the readings in the main beam higher although hopefully subtracting out the background reading reduces most of this error. Since all the readings in the beam profile are relative, this tends to give the readings outside the main beam smaller relative values than they would otherwise have. The end result is actually a lower total lumen value. It would be interesting to retest a few LEDs if I modify my apparatus to see if I actually end up with higher lumen values.

Quote

08-05-2006, 09:14 PM #57

milkyspit
Flashaholic*

Join Date: Sep 2002
Location: New Jersey
Posts: 3,024

Re: White LED lumen testing

Quote:

> Originally Posted by **jtr1962**
> *I'm actually thinking of doing that because that long image is getting unwieldy. I simply have to see how much web*

> *space separate images versus one large one would take up as Roadrunner only gives me 5 MB of web space. It would make my life easier in that I wouldn't have to edit that huge picture every time I test a new LED.*

If it gets down to it, maybe I could give you some space on my hosting account, or at least point you to a hosting provider where $10 per month would buy you something along the lines of 150-300MB of space. Let me know if you need the help... glad to assist!

--Scott


Milkyspit: Be Very Afraid.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08-05-2006, 10:09 PM #58

jtr1962
Flashaholic*

Join Date: Nov 2003
Location: Flushing, NY
Posts: 1,925

Re: White LED lumen testing

Quote:

> Originally Posted by **milkyspit**
> *If it gets down to it, maybe I could give you some space on my hosting account, or at least point you to a hosting provider where $10 per month would buy you something along the lines of 150-300MB of space. Let me know if you need the help... glad to assist!*

So far so good-the separate files for the white LEDs were only about 15K more than the one big file. The white LED efficiency charts are now separate pictures. Stay tuned for the colored LEDs...

Update: The colored LED efficiency charts are now separate files. They actually use less space than the one big file since I was able to convert most of them to 16 colors.

Second Update: LED comparison charts are now separate images.

Third Update: Power white LED charts now separate images. I think that takes care of everything.

Last edited by jtr1962 : 08-05-2006 at 11:32 PM.

Quote

Yesterday, 06:32 PM #59

jtr1962
Flashaholic*

Join Date: Nov 2003
Location: Flushing, NY
Posts: 1,925

Re: White LED lumen testing

I adding the following chart summarizing my results at 20 mA to the first post:

LED	Beam angle	Vf (volts)	Intensity (mcd)	Output (lumens)	Efficiency (lm/W)	Date Tested	Date of Manufacture
Nichia 5600 mcd 5mm	13.9°	3.33	11100	1.87	28.1	July 2005	2001
Spectrum LEDs 6000 mcd 5mm	17.3°	3.28	4500	1.44	22.0	July 2005	May 2003
ChiWing 5000 mcd 3mm	32.6°	3.19	1400	1.38	21.7	July 2005	July 2003
ChiWing 8000 mcd 5mm	15.2°	3.04	9800	2.15	35.4	July 2005	July 2003
BestHongKong 10000 mcd 5mm	11.8°	3.41	16500	2.56	37.5	July 2005	February 2004
Spectrum LEDs 8000 mcd 5mm	16.0°	3.13	4700	1.33	21.3	July 2005	November 2004
wardenjp_2002 26000 mcd 5mm	16.0°	3.18	23900	4.72	74.2	July 2005	February 2005
Hebei L5B47VW5C 60° 5mm	61.3°	3.21	1750	2.26	35.2	July 2005	March 2005
LCK 12000 mcd 5mm	13.3°	3.32	20200	3.84	57.8	July 2005	July 2005
BestHongKong 25000 mcd 5mm UWLC series	14.5°	3.27	16300	2.81	43.0	July 2005	July 2005
Light of Victory 35000 mcd 5mm	13.7°	3.13	23400	3.76	60.1	July 2005	July 2005
LCK warm white 12000 mcd 5mm	15.5°	3.11	18200	3.61	58.1	July 2005	July 2005
Jeled 40000 mcd 5mm	13.2°	3.31	30800	4.64	70.0	December 2005	December 2005
BestHongKong 40000 mcd 5mm	16.9°	3.40	20200	4.50	66.1	January 2006	January 2006
Jeled 50000 mcd 5mm	12.8°	3.40	41100	5.59	82.3	January 2006	January 2006
Peak Snow 29 5mm	16.7°	3.20	21300	5.11	79.8	February 2006	February 2006
Nichia CS bin B1U 5mm	16.2°	3.24	24100	4.83	74.5	February 2006	February 2006
MPJA 15000 mcd 10mm	8.4°	3.04	61700	3.69	60.9	July 2006	February 2005
unknown 26000 mcd 5mm	17.2°	3.26	16800	4.02	61.6	July 2006	November 2005
LS Diodes THC3 quad-die 5mm	27.4°	2.82	8300	4.11	72.8	July 2006	July 2006
SMJLED quad-die 5mm	31.6°	2.78	7100	4.88	87.8	July 2006	June 2006
Nichia NSPW310BS-E 60° 3mm	50.9°	3.29	2600	2.38	36.2	August 2006	August 2006

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