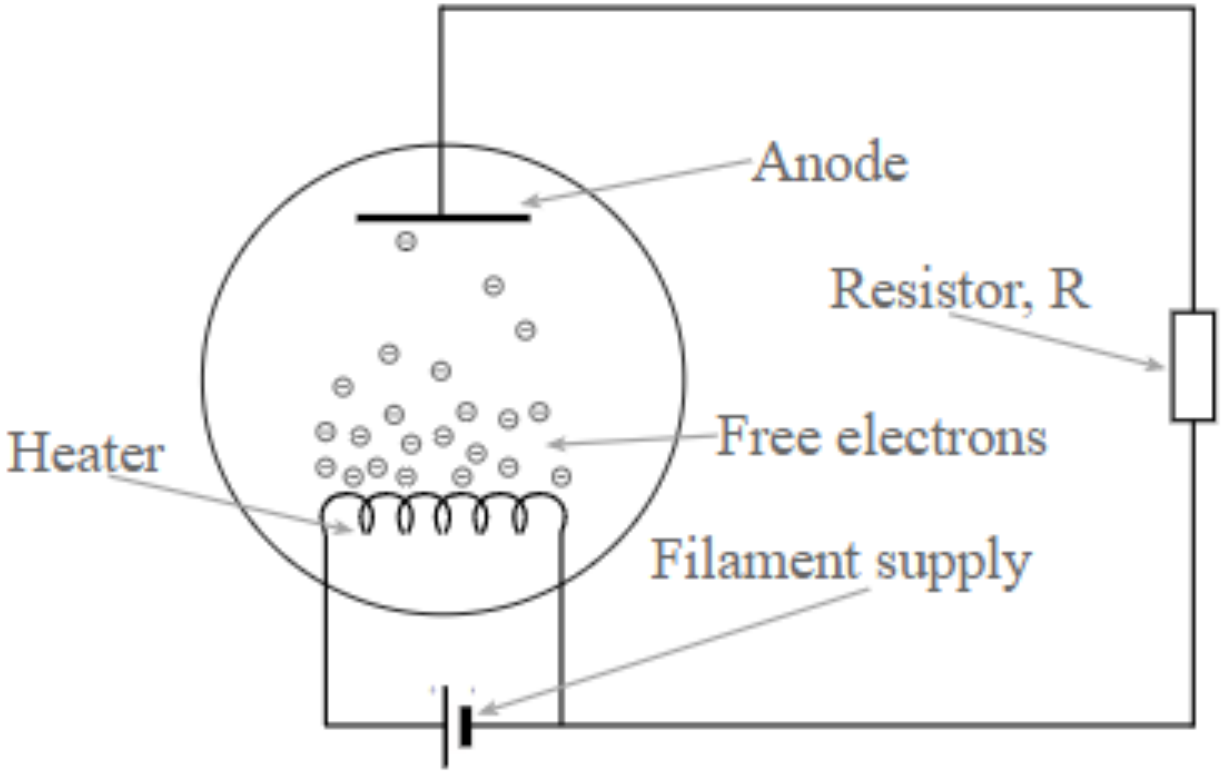
Light Emitting Diodes (LED)

MARC BERNHARDT

Vacuum Tube Diode

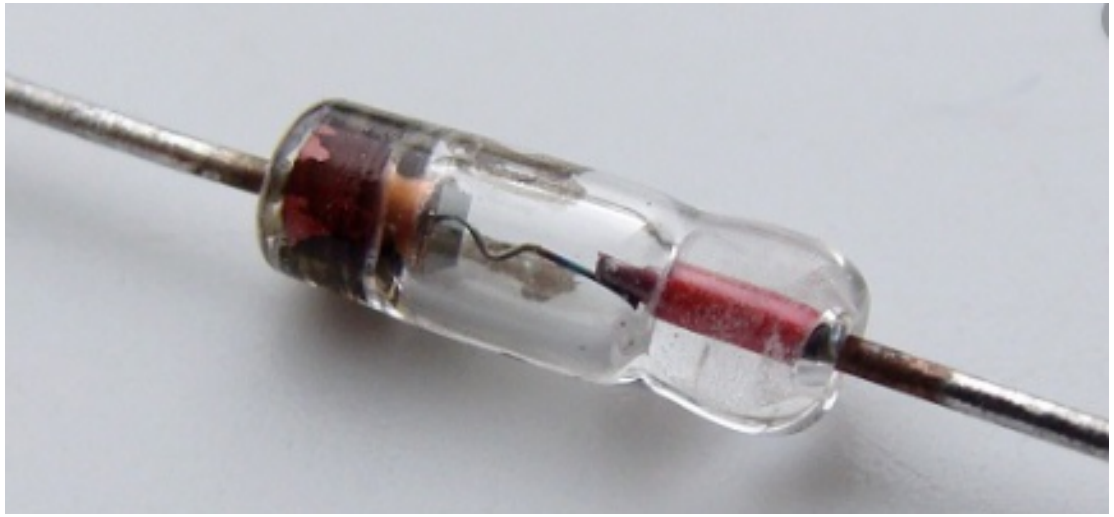


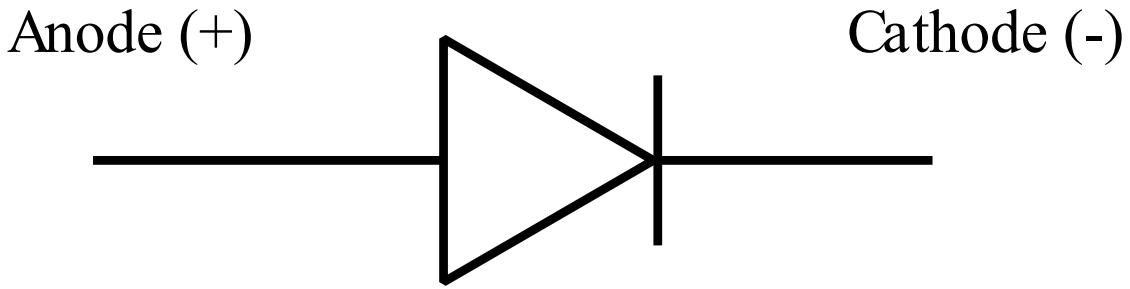
Electrons “boil off” from the heater (cathode) and flow to the anode.

Current can only flow from the anode to the cathode.

Photos: Electronics-notes.com

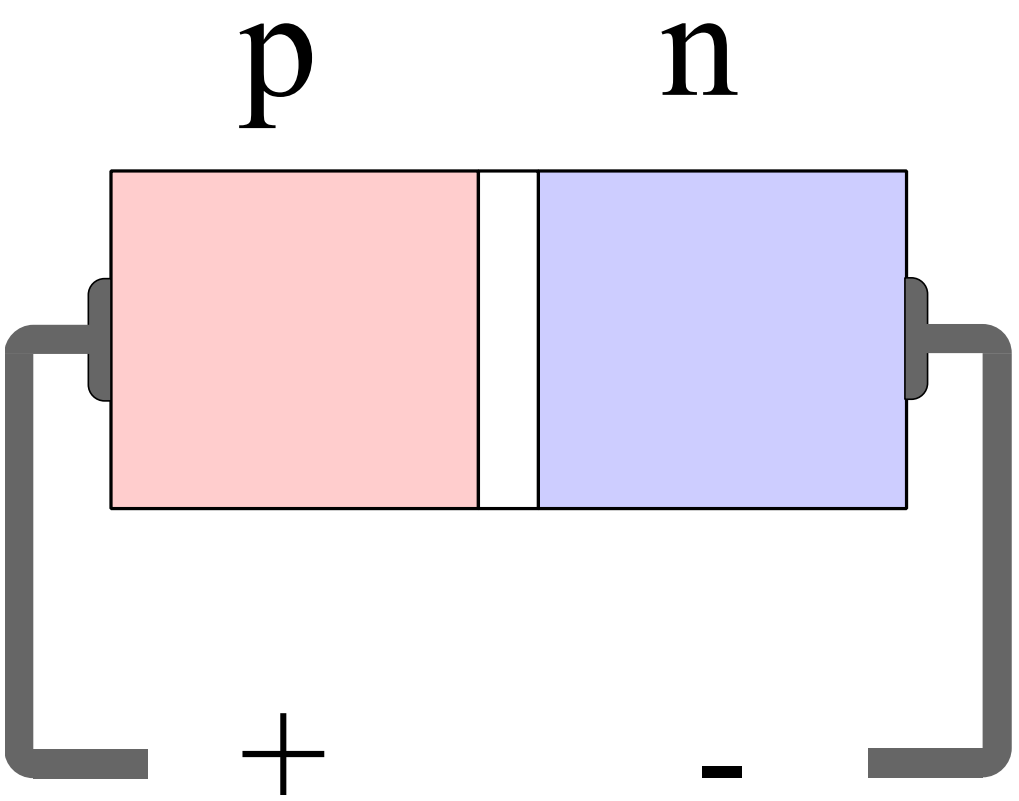
Semiconductor Diode

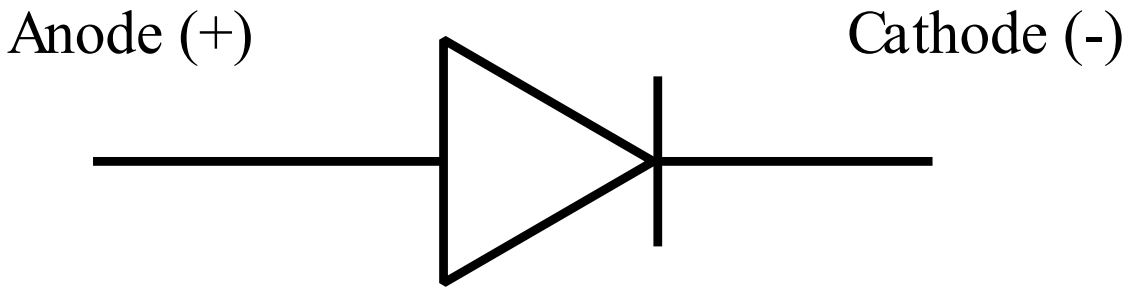




Current can only flow from the anode to the cathode.

Semiconductor Diode

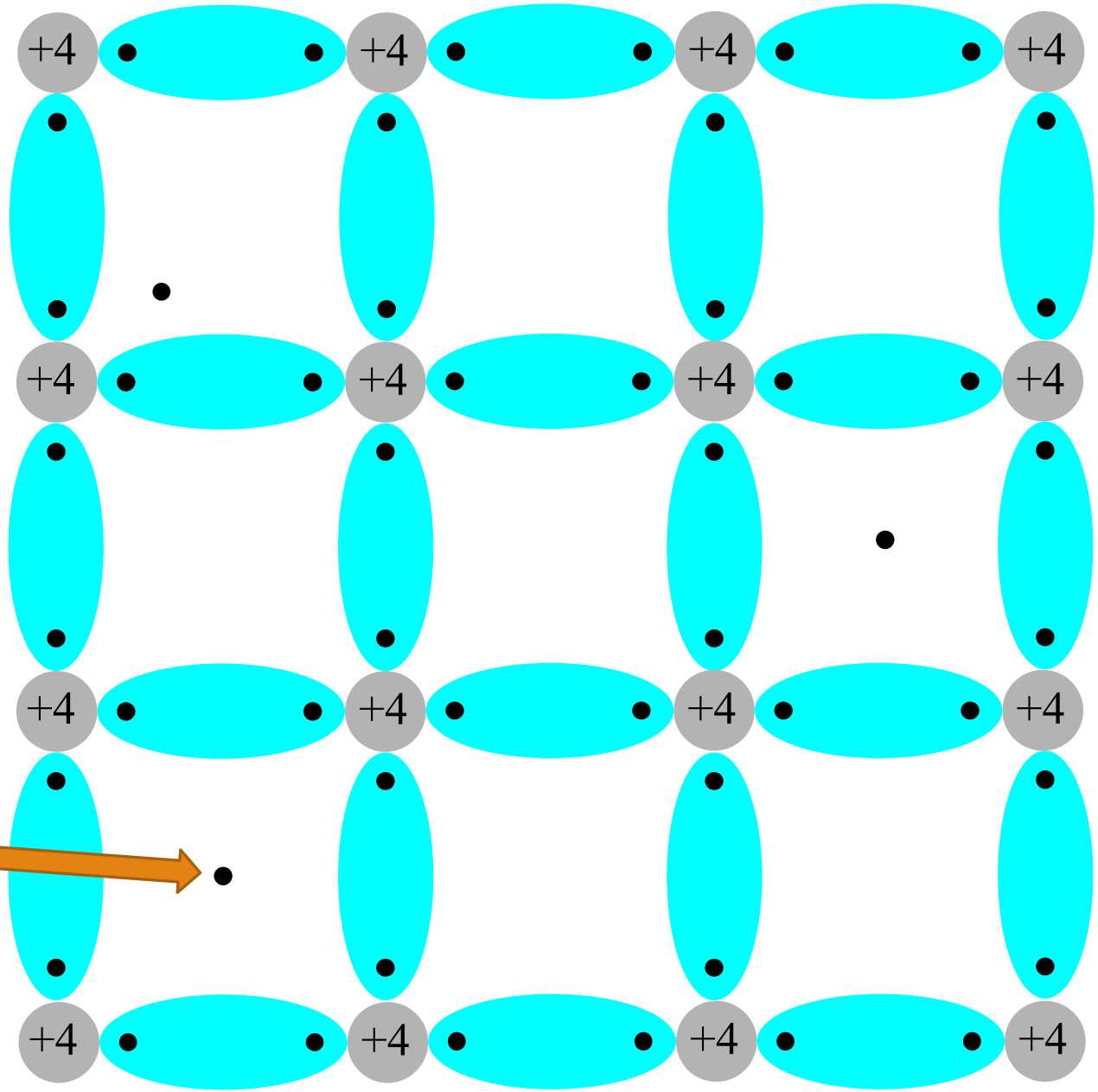




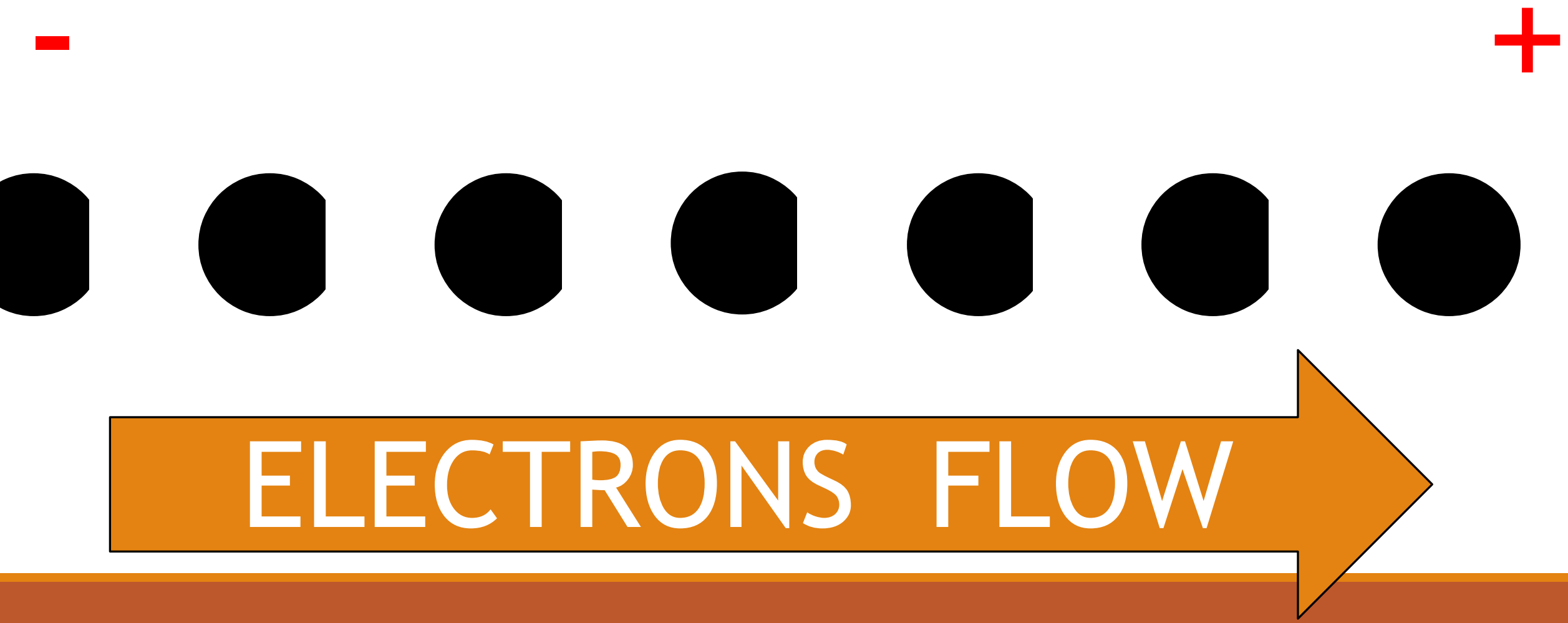
Current can only flow from the anode to the cathode.

Silicon Lattice

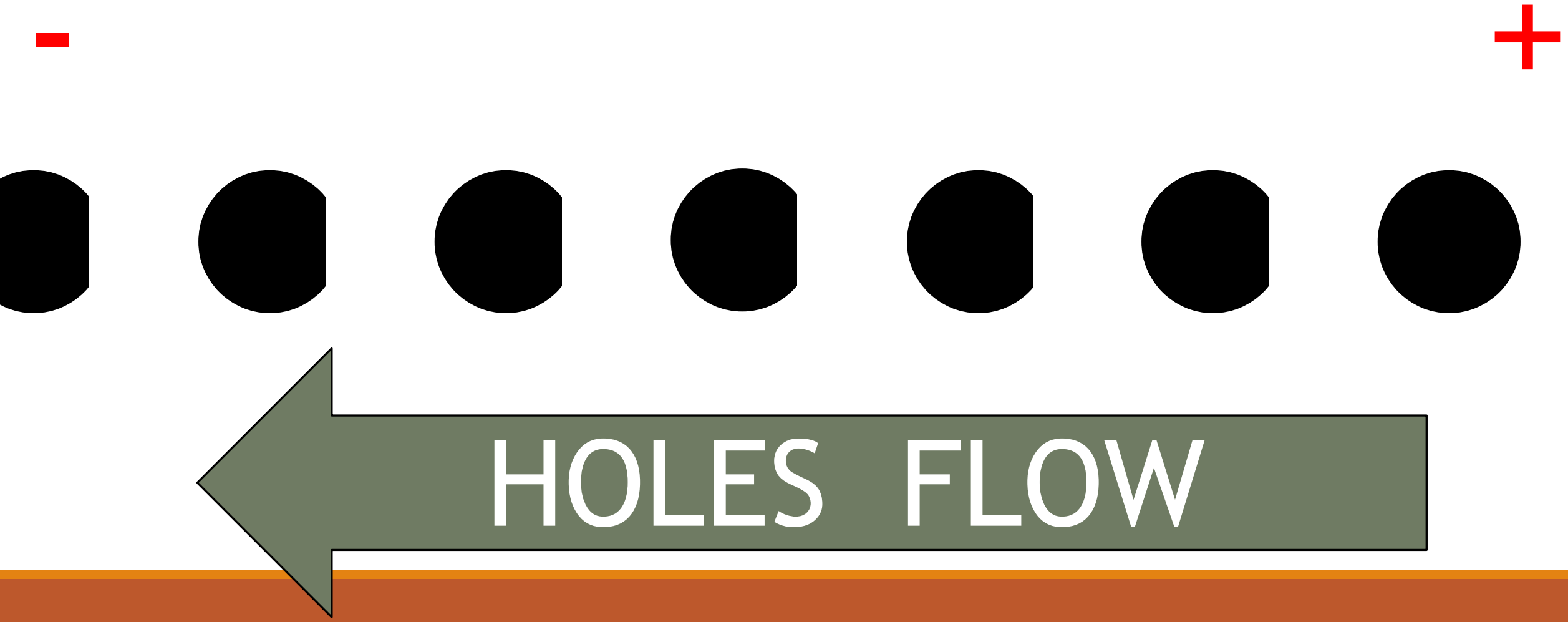
Free Electron



Apply Voltage to Silicon Lattice



Apply Voltage to Silicon Lattice



Periodic Table of the Elements

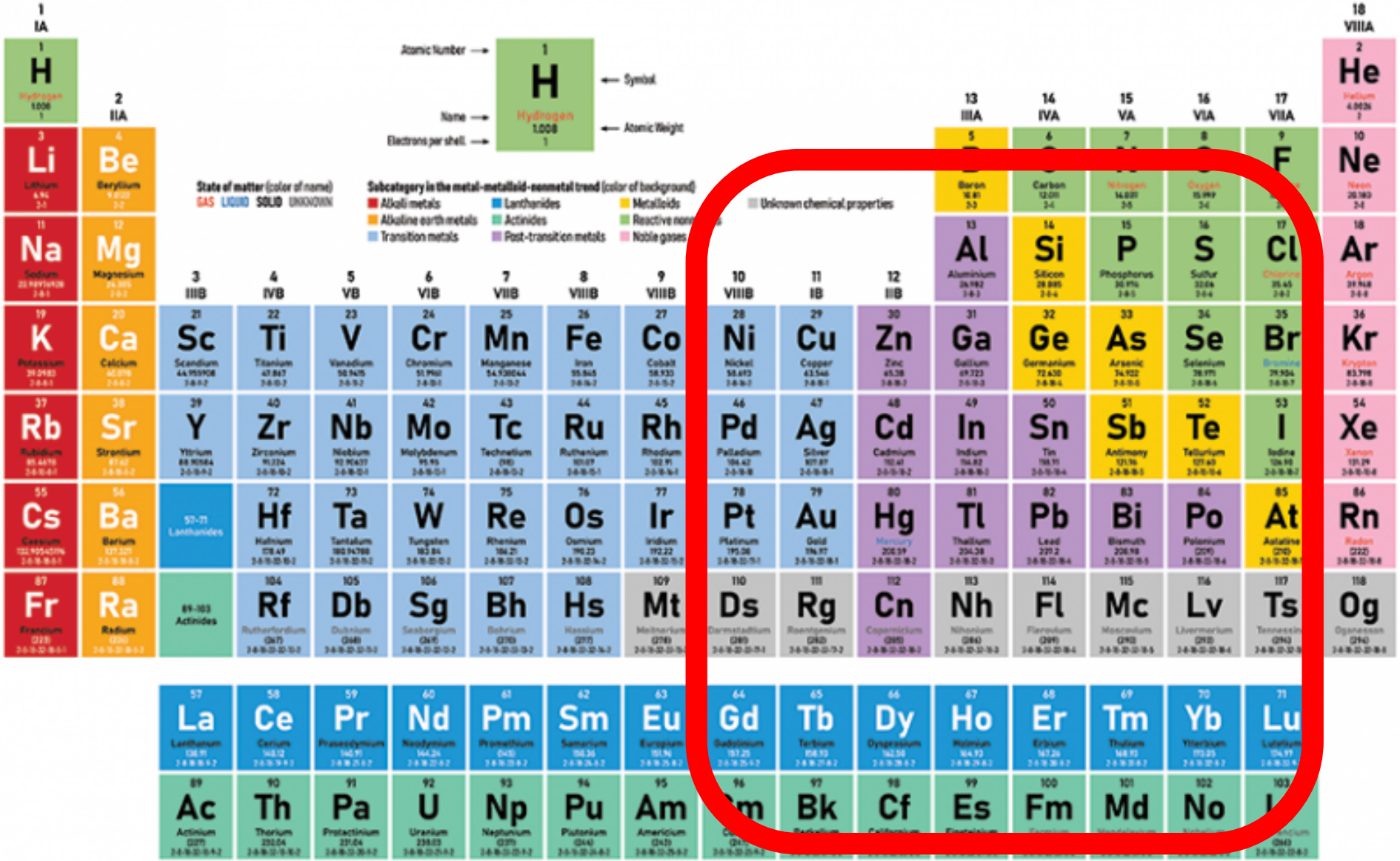
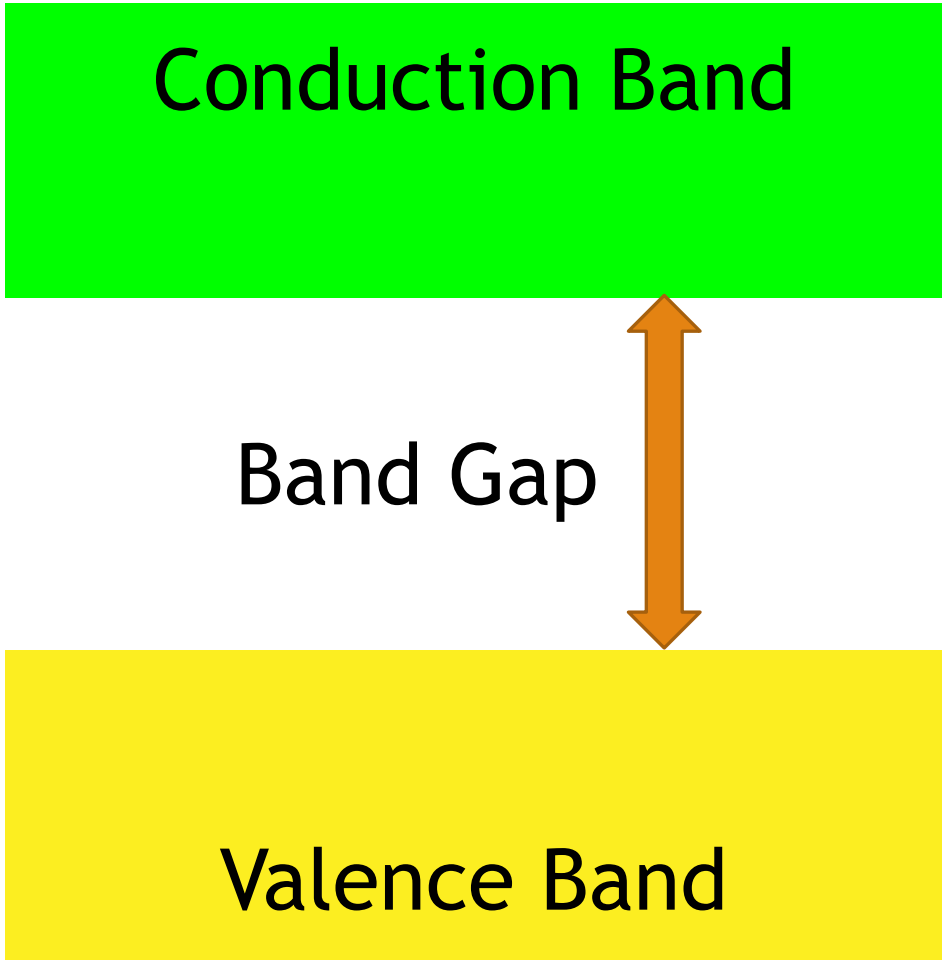
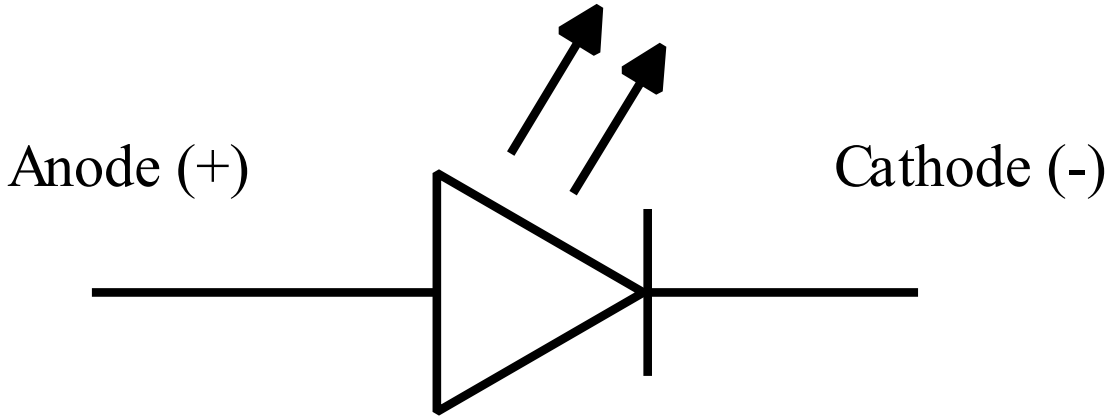
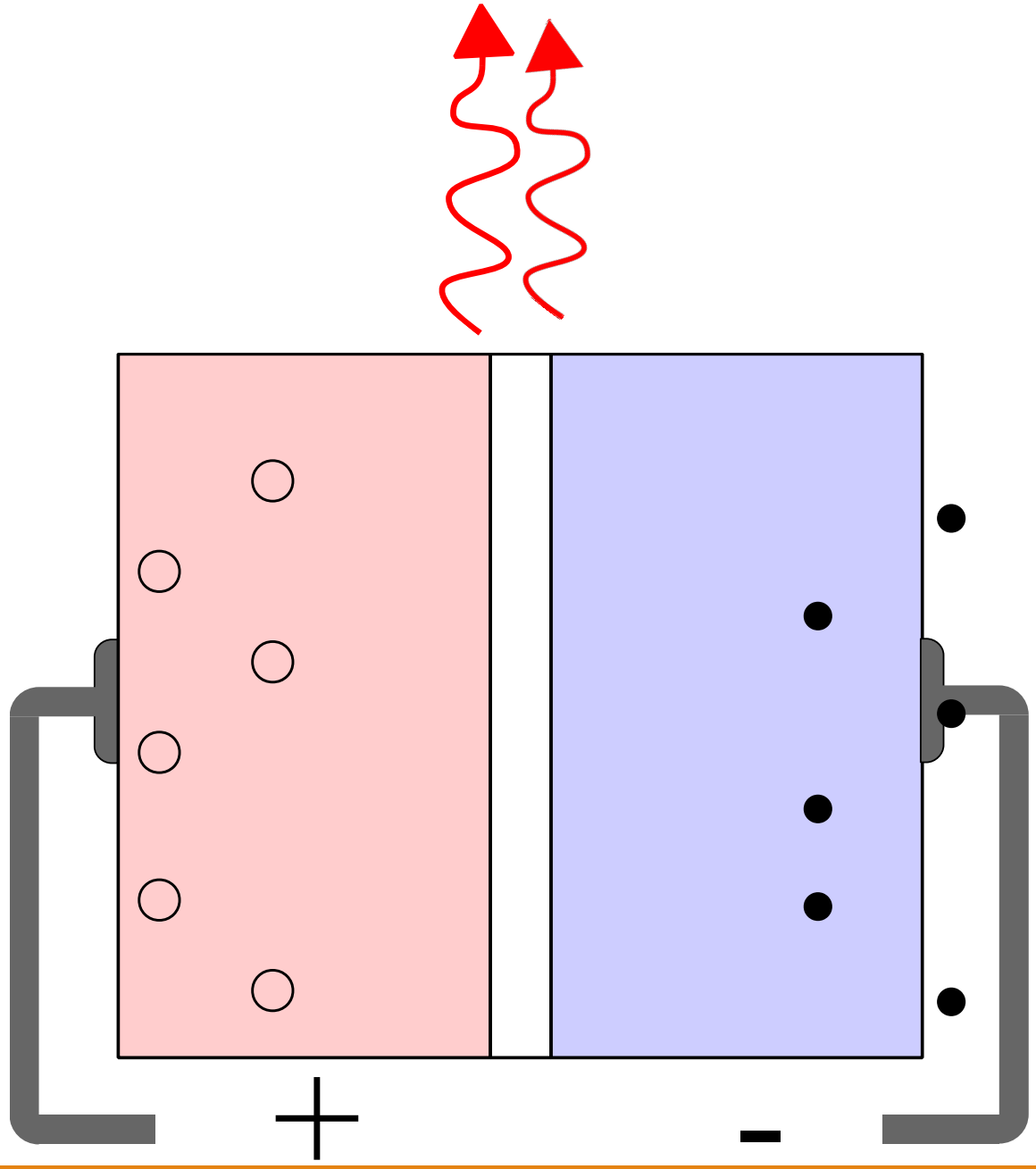


Photo: Scienceforstudents.org

Semiconductor Electron States

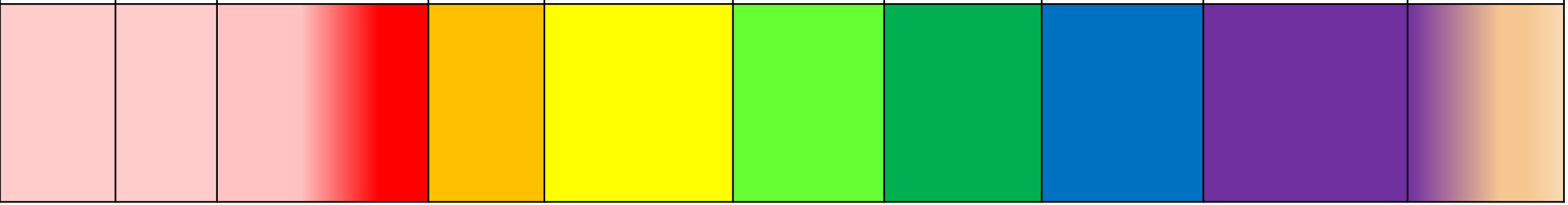






The Chemistry Determines the Wavelength

Ge	Si	AlGaAs	InP	GaAsP	GaAs	GaP	ZnSe	InGaN	ZnS
0.7	1.1	1.7	2.1	2.13	2.2	2.3	2.7	3.4	3.9

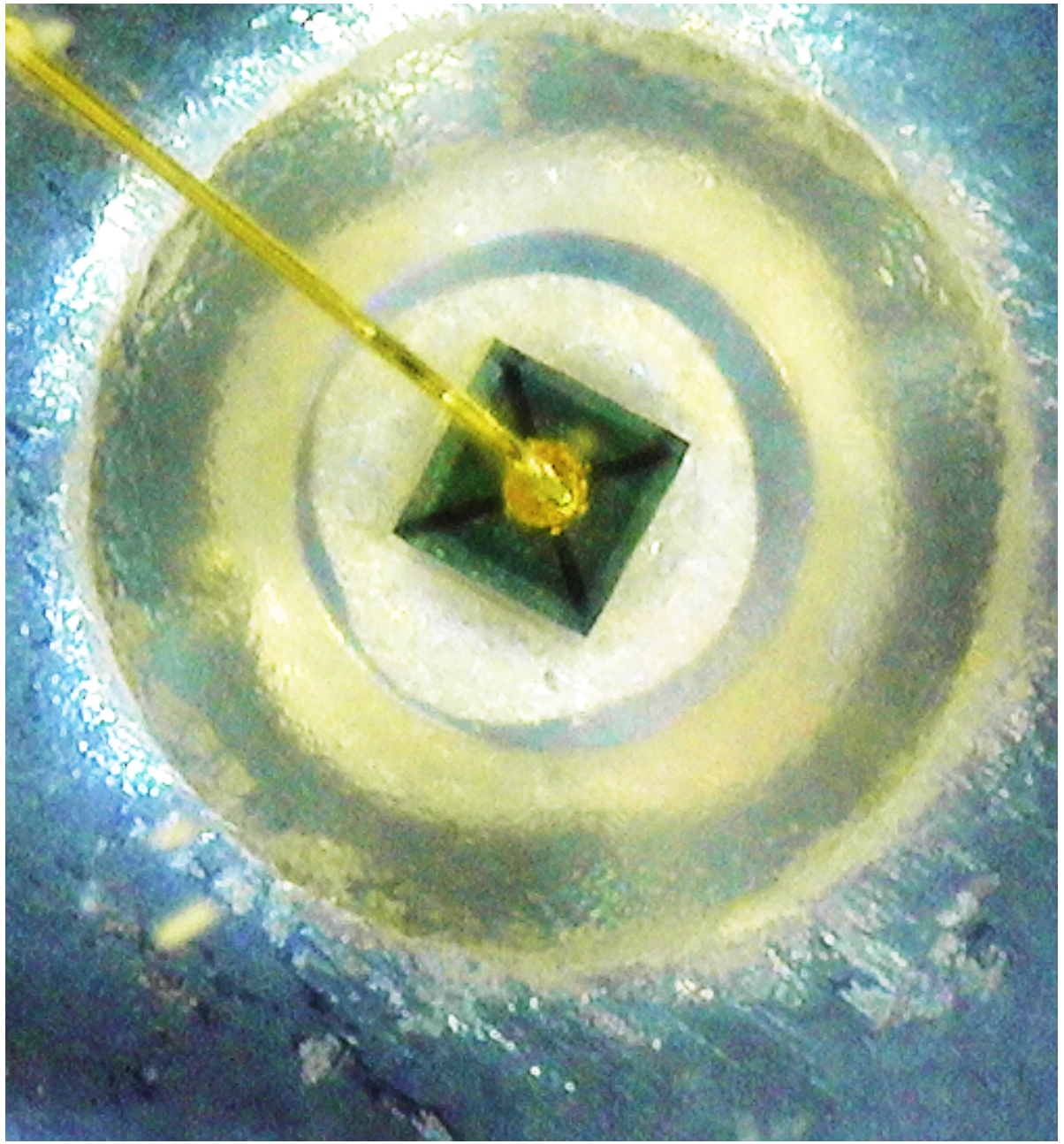


$$\text{Wavelength (nm)} \quad \frac{1241}{\text{Band Gap (eV)}}$$

Blue LED

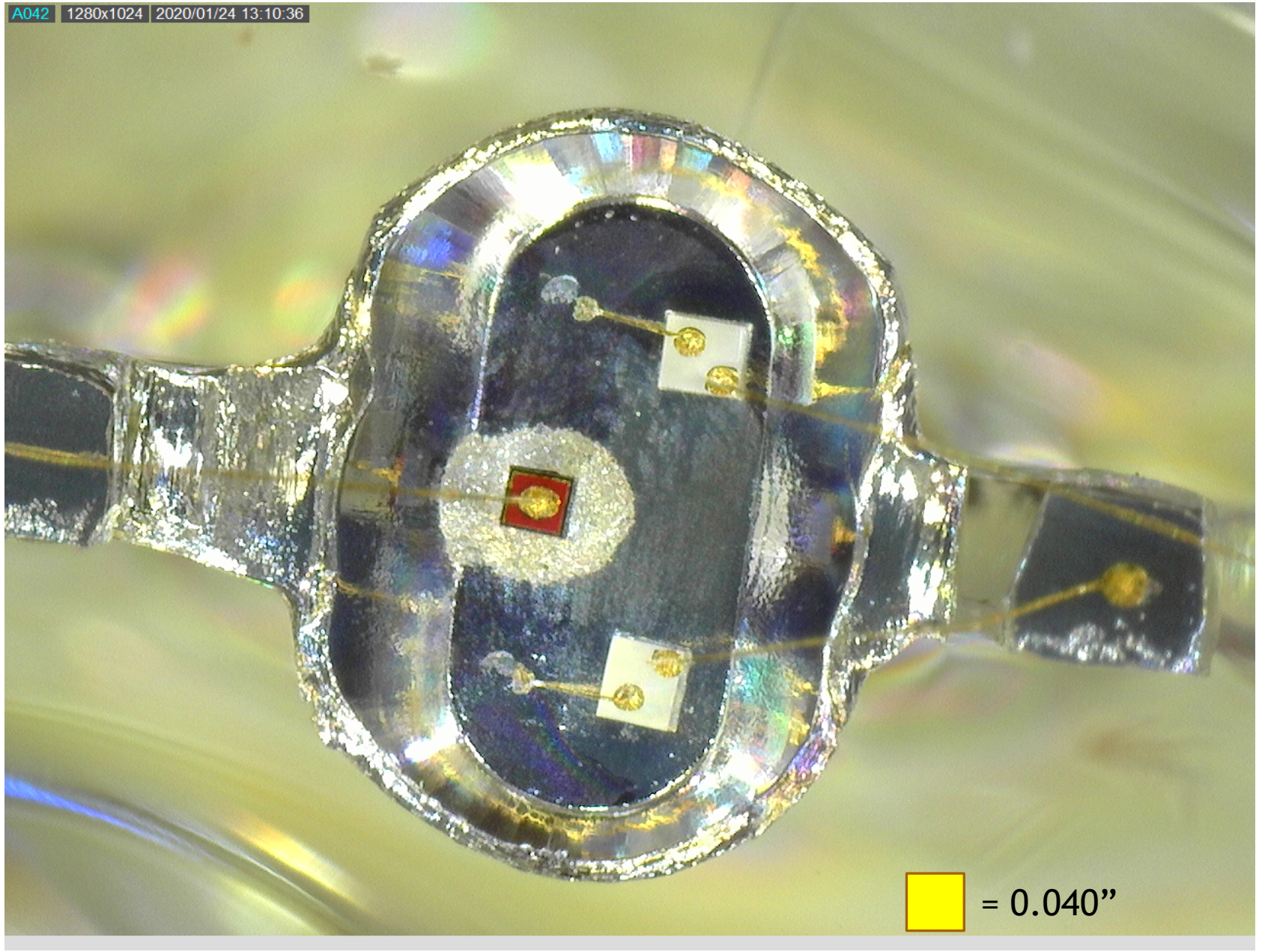
Au wire is ultrasonically bonded to the die.

Nobel Prize 2014.



RGB LED

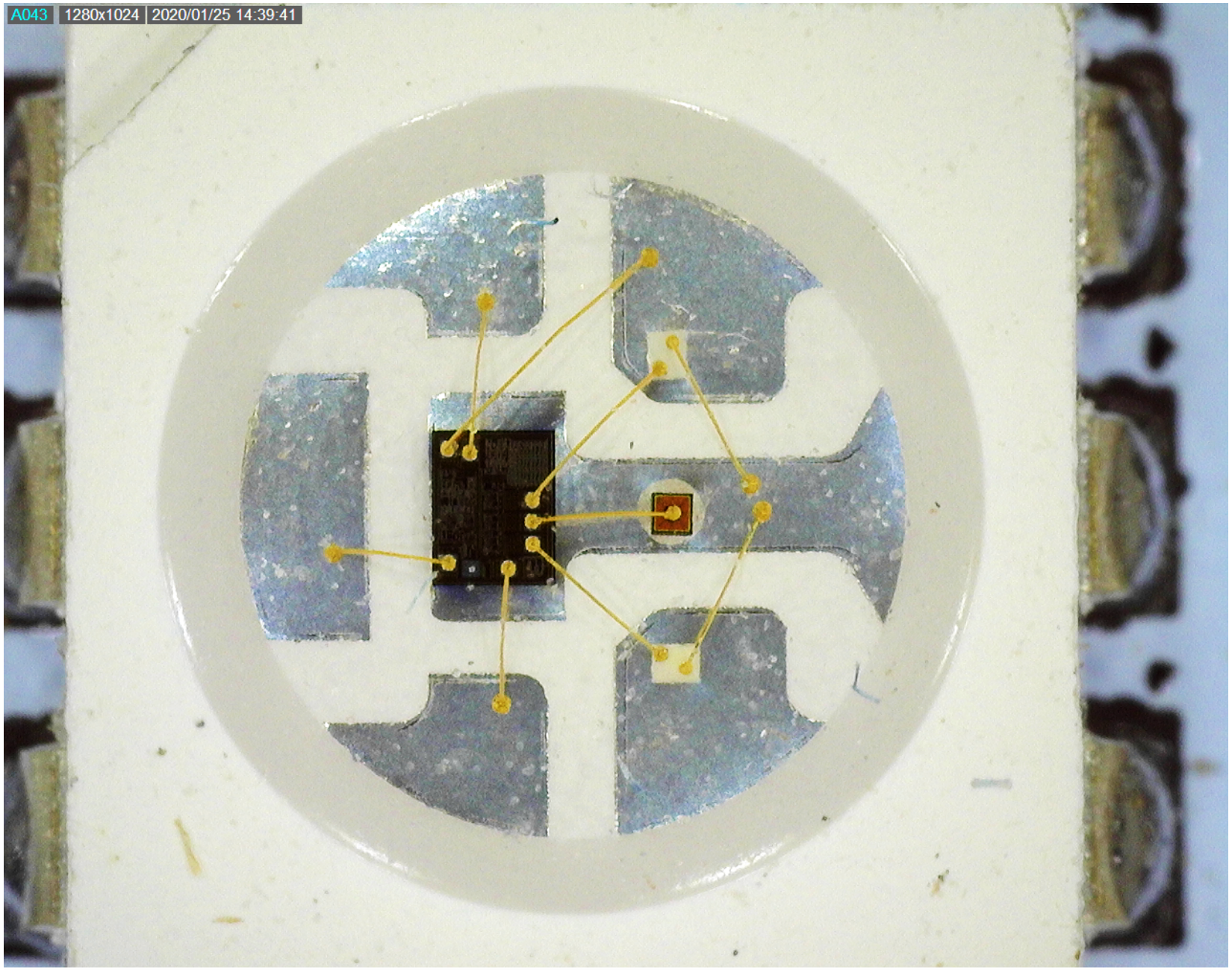
Three individual LED dice are combined to produce any color light, including white.



RGB LED

RGB LED

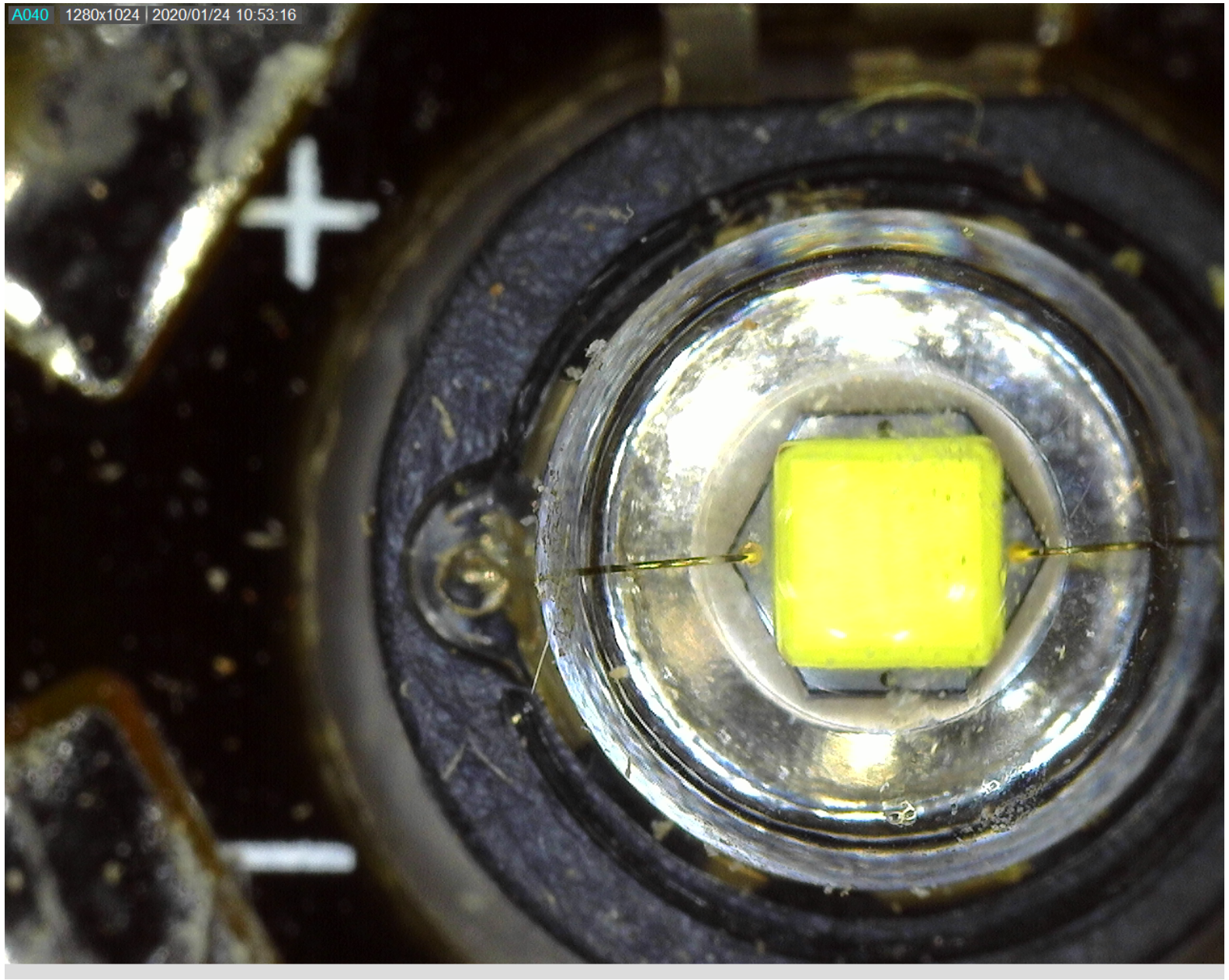
Three individual LED dice are connected to an integrated circuit.



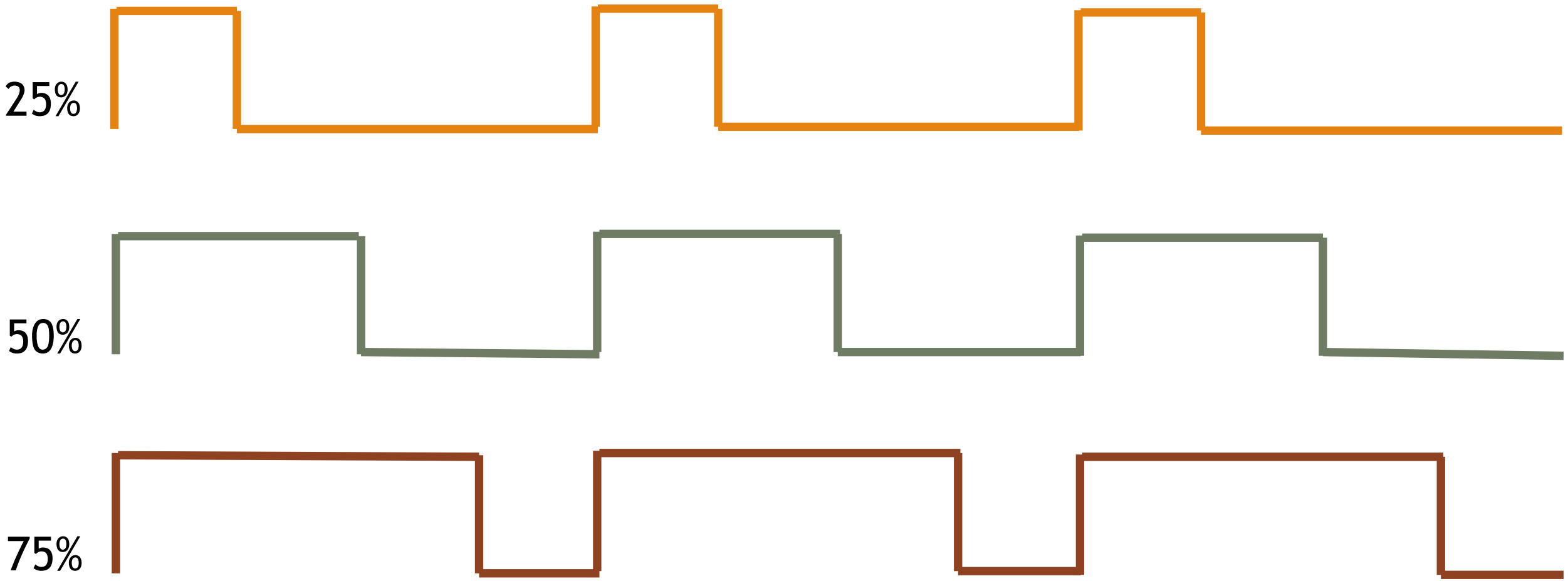
White LED

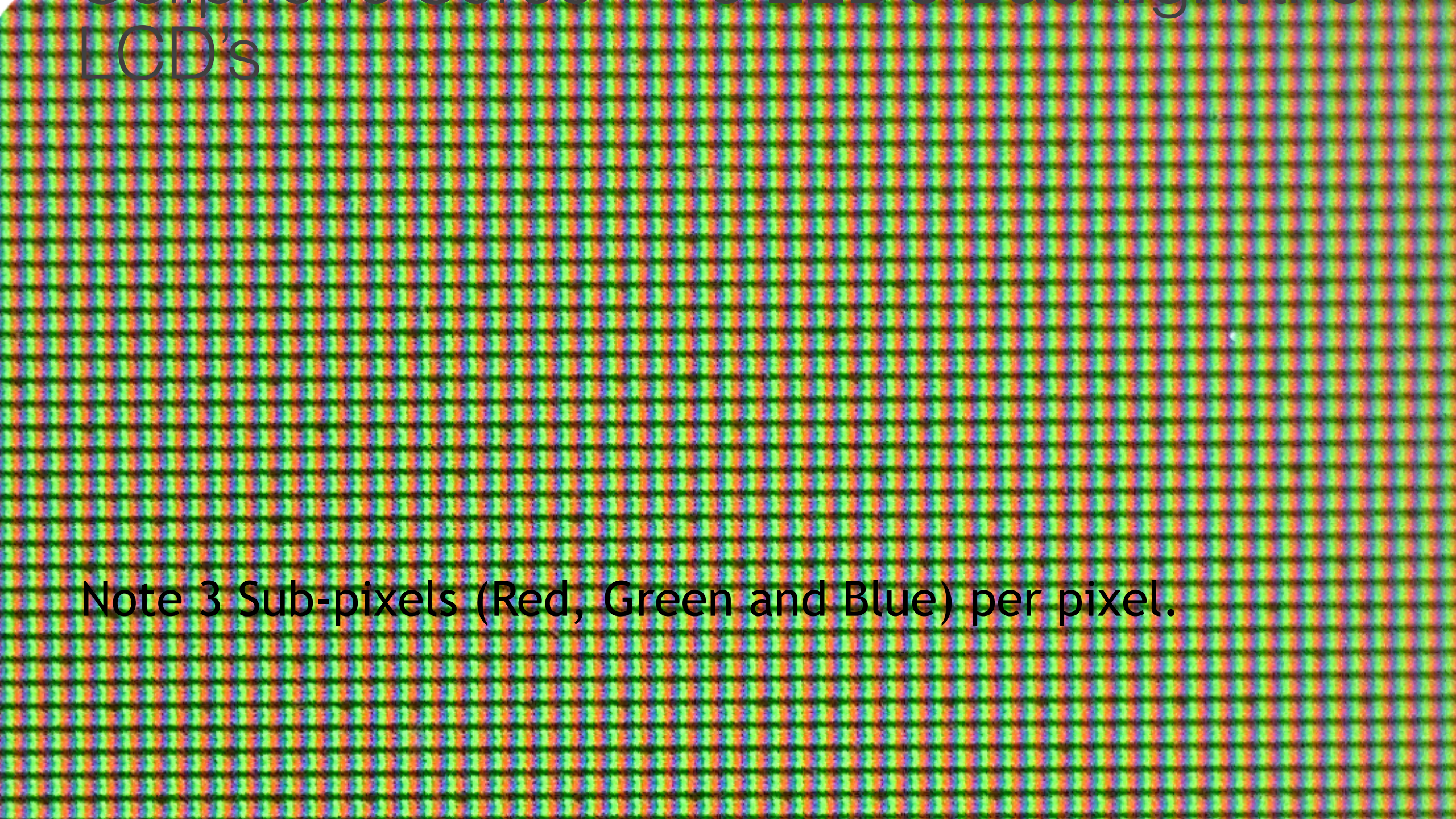
Note the yellow phosphor coating on the die.

The color temperature of a “white” LED is determined by the emission spectrum.



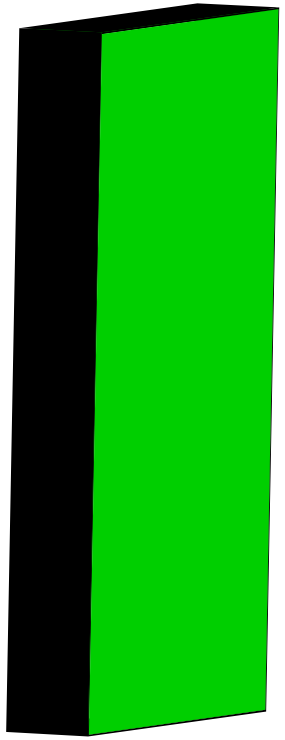
Dimming LED's with Pulse Width Modulation



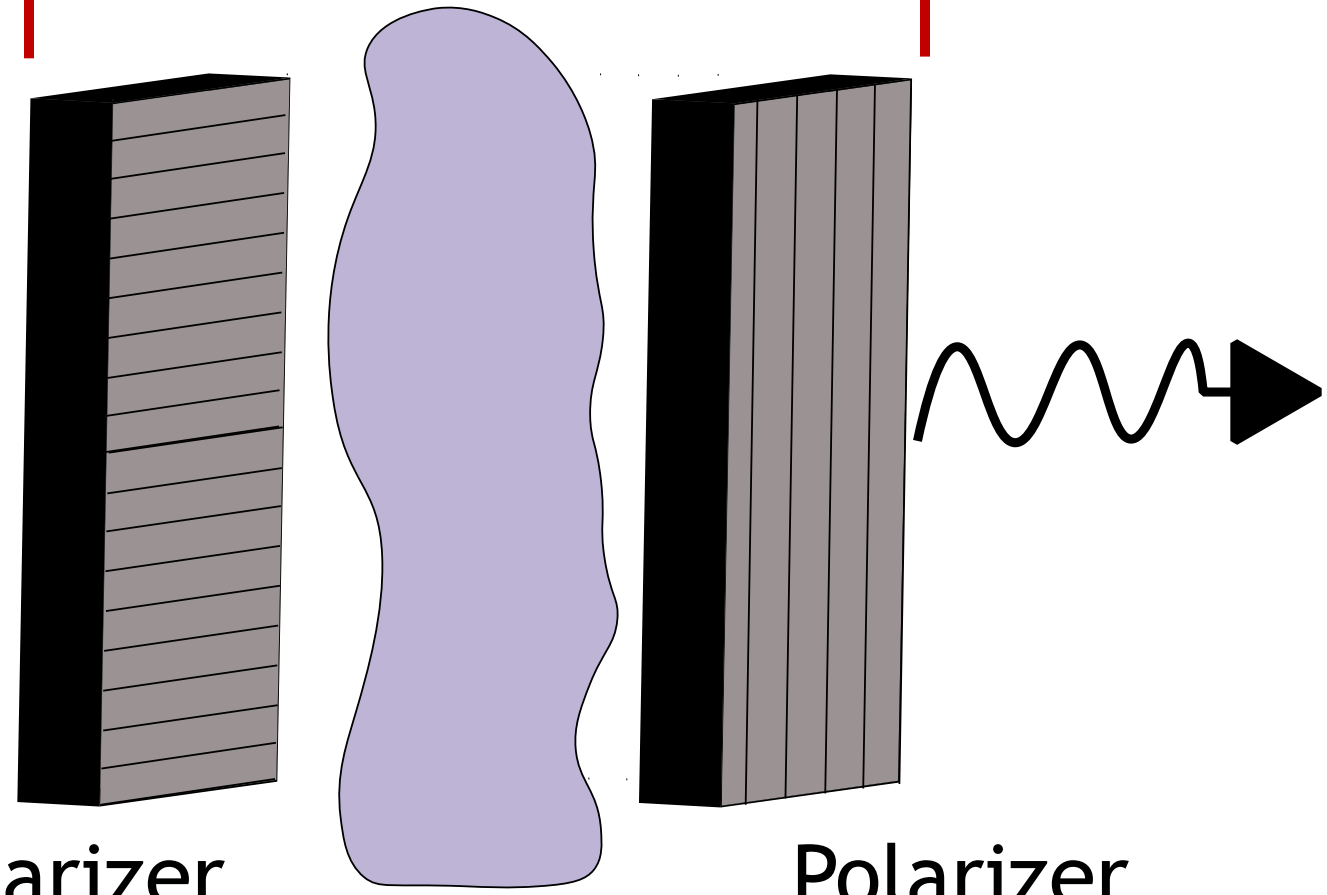

LCD's
Note 3 Sub-pixels (Red, Green and Blue) per pixel.

LED TV Screen

Each pixel has 3 sub-pixels.



LED
Sub-pixel



8 Bit Digital Color

Example: 11111111 (bright white)

8 bit color = 2^8 = 256 unique light levels.

Each sub-pixel has 256 unique light levels.

Each pixel can have = 256 x 256 x 256

$=2^{24}$

= 16,777,216 col

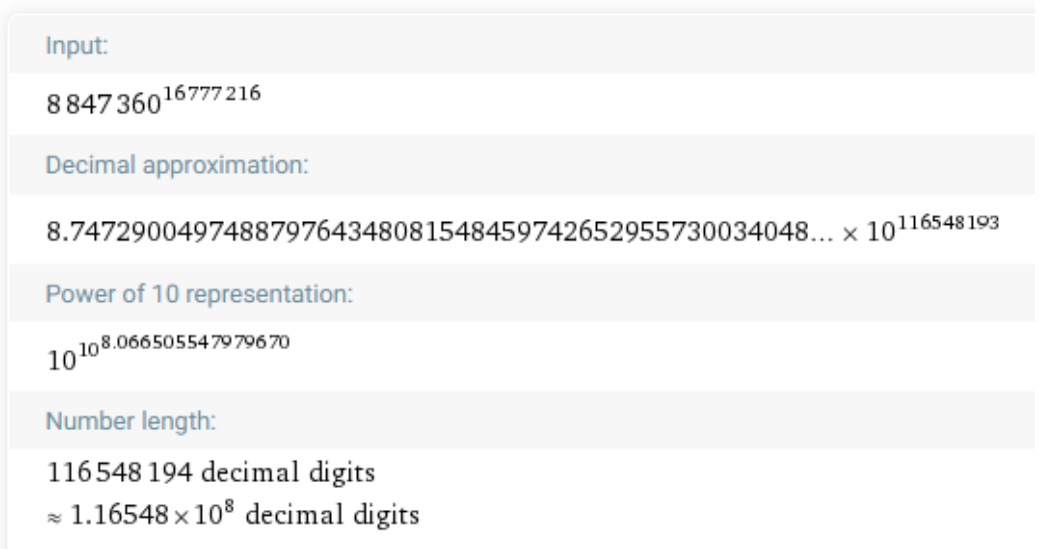
TV Screen: How many images can a TV display?

4K TV Screen is 4096 x 2160 pixels = 8,847,360 pixels

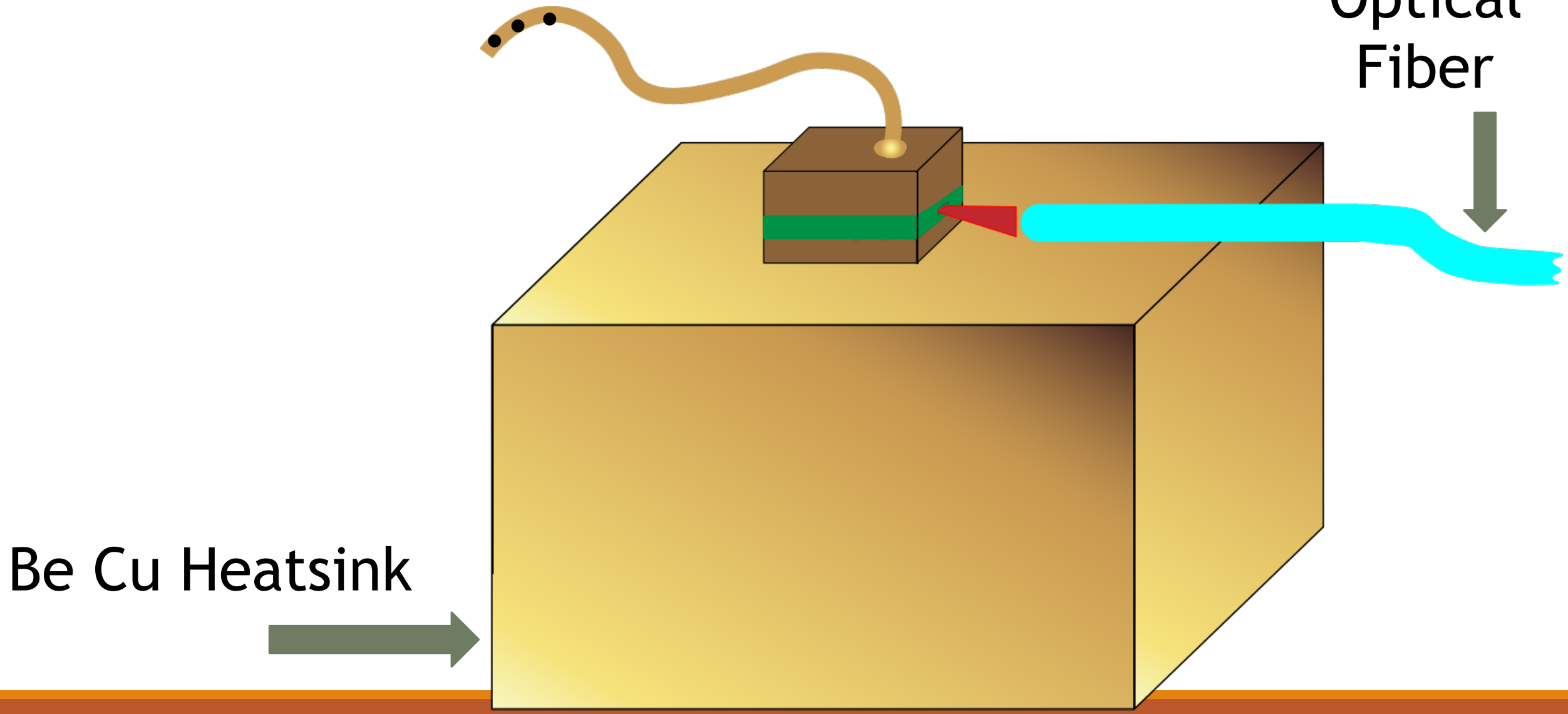
Total images possible on a TV screen is:

$$16{,}777{,}216^{8{,}847{,}360}$$

Using Wolfram Alpha, this is a number with more than **116 million digits.**



Laser Diode



Thank You!