

Learning by trying

<https://hackuarium.github.com/inartis>

oceane@patiny.com

florian@patiny.com

luc@patiny.com



UNIVERCITÉ
POWERED BY **INARTIS** FOUNDATION



Microtechnics

Architecture

**Civil
Engineering**

Physics

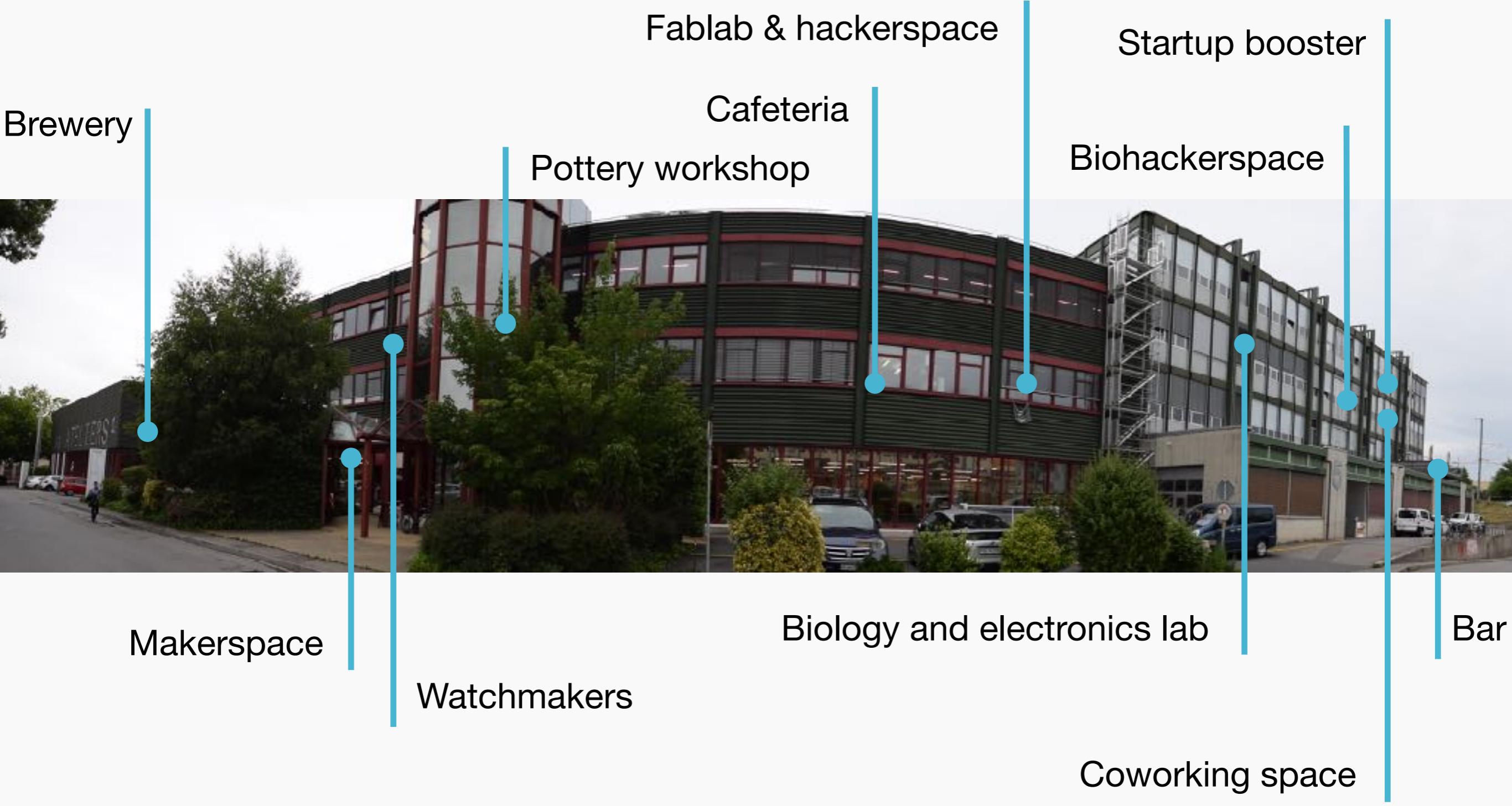
Life Science

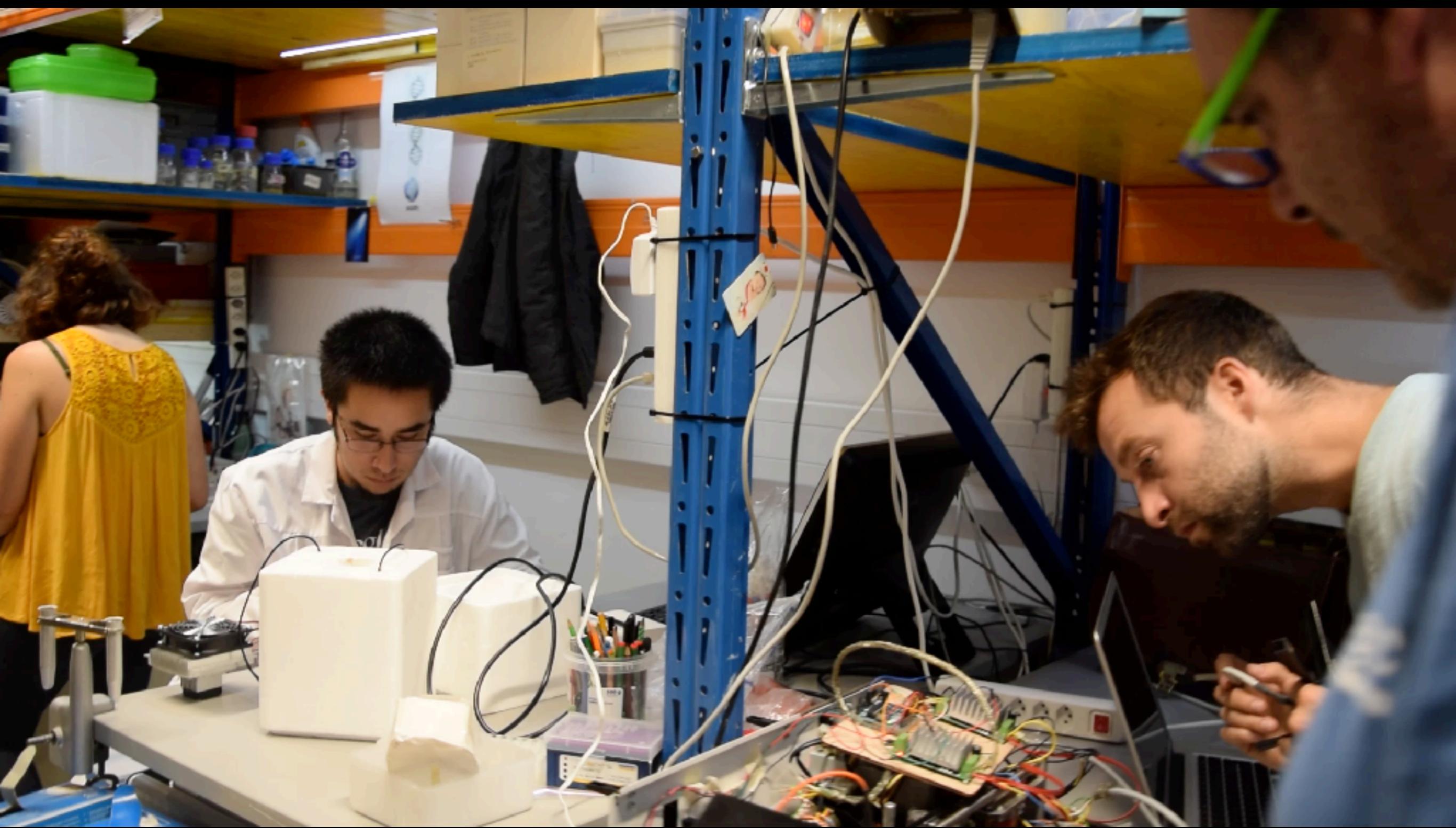
Mathematics

Chemistry

**Computer
Science**

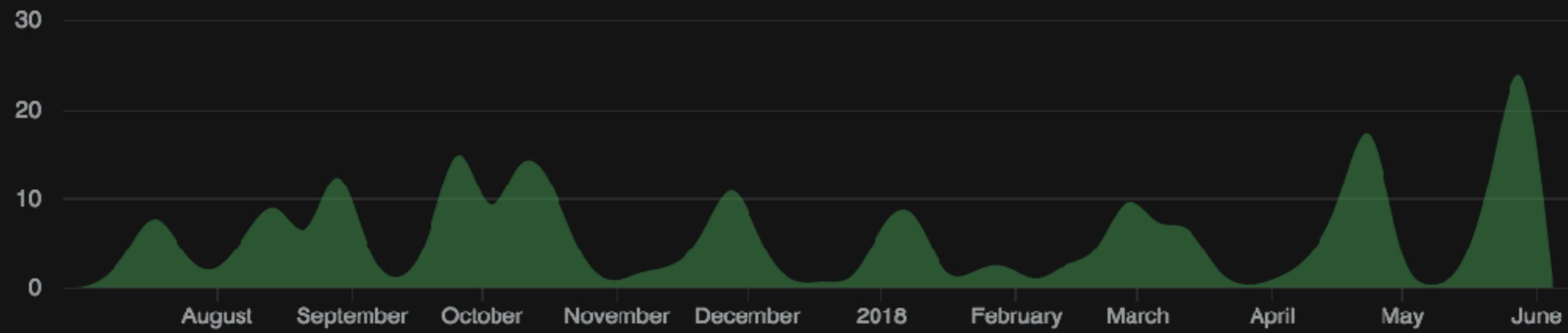
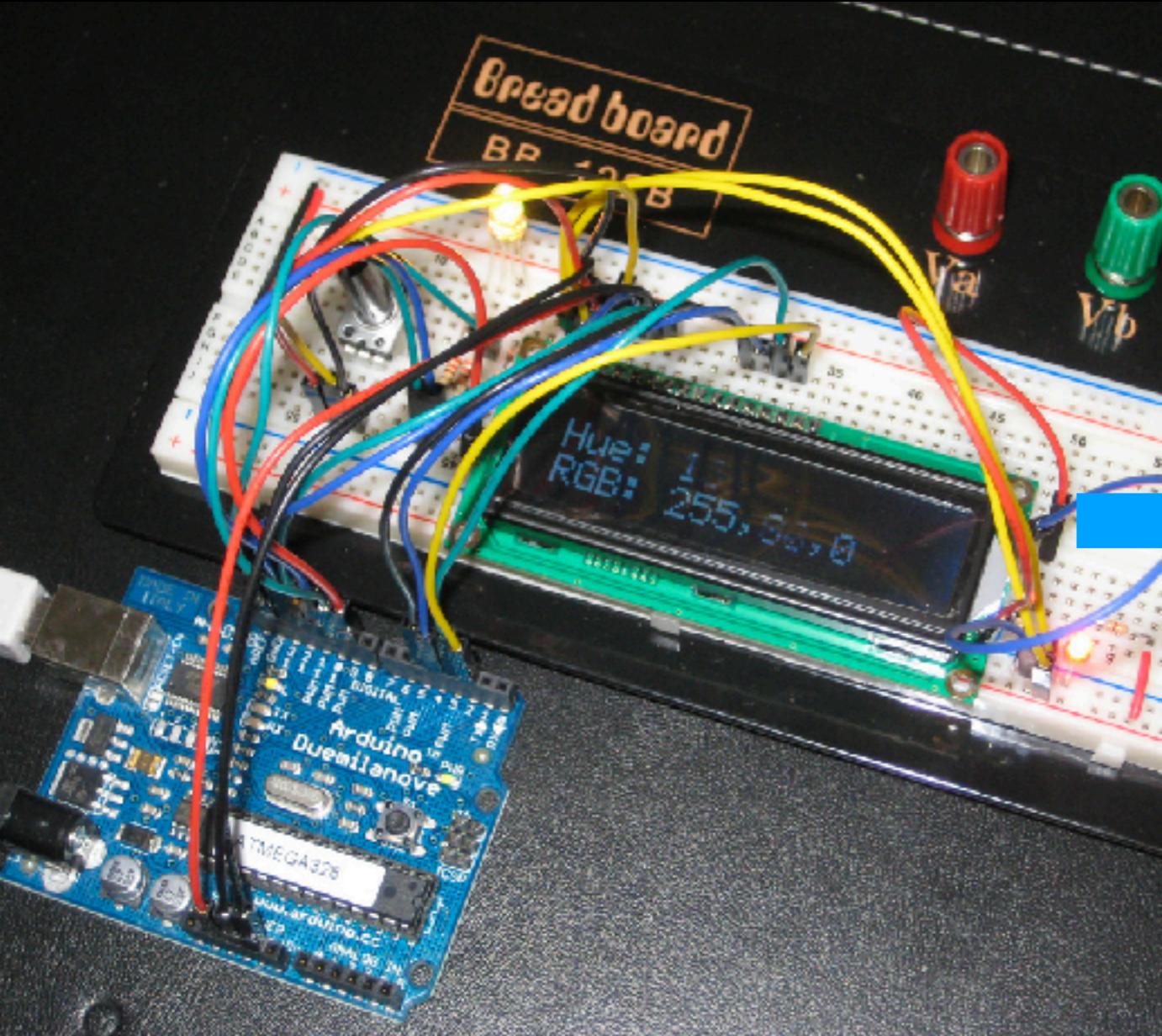
**Electrical
Engineering**

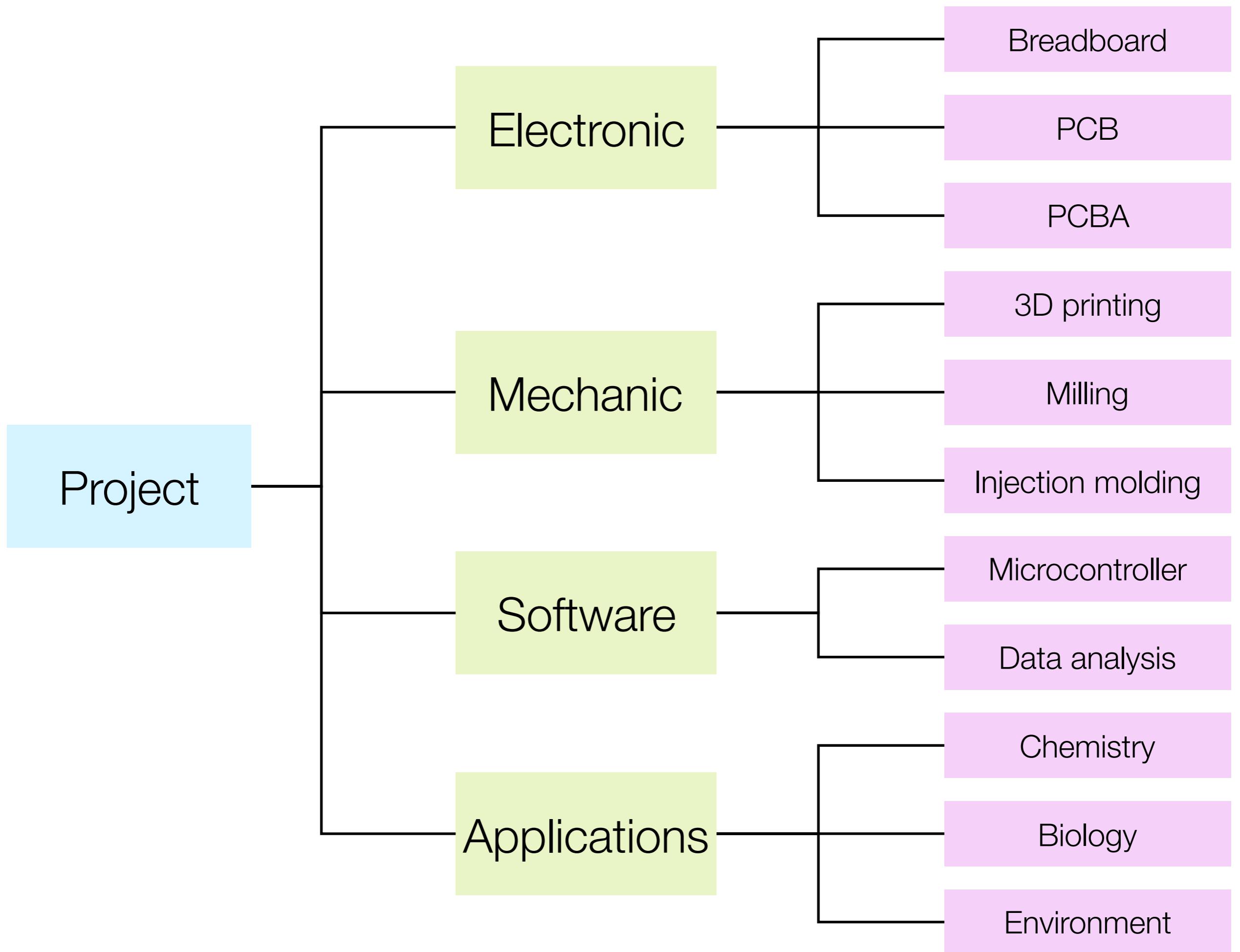




Hackuarium

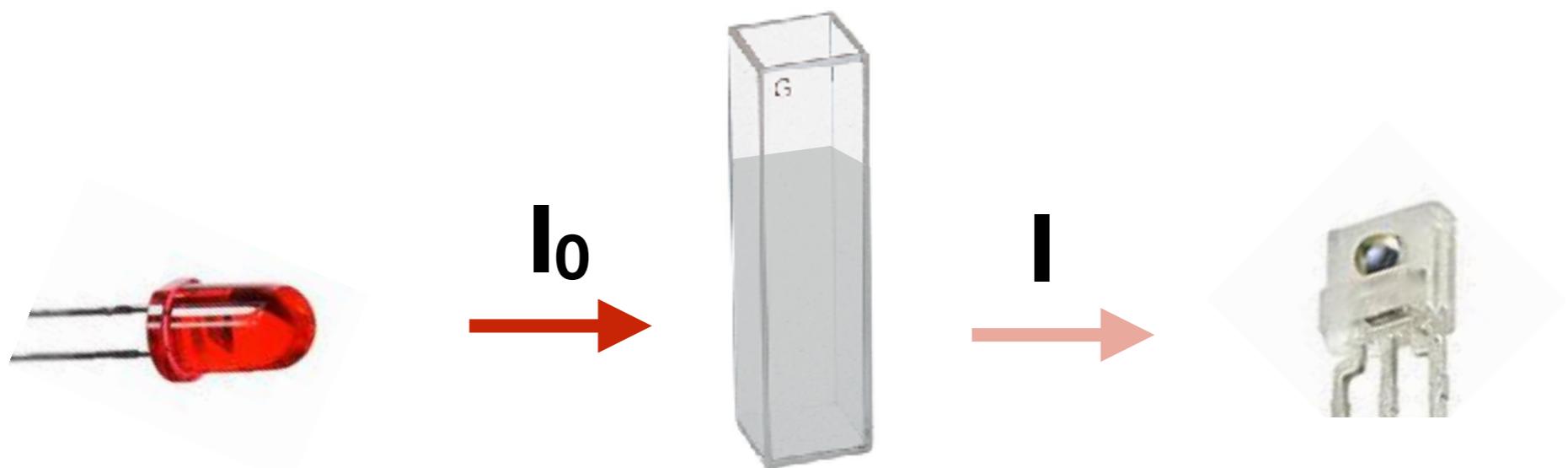
- Interdisciplinary
- No commercial pressure: we have time to learn
- Open-source and public documentation (GitHub, wiki)
- Societal activities
- Real wish to share knowledge
- Fun
- Rigour yielding to scientific publications



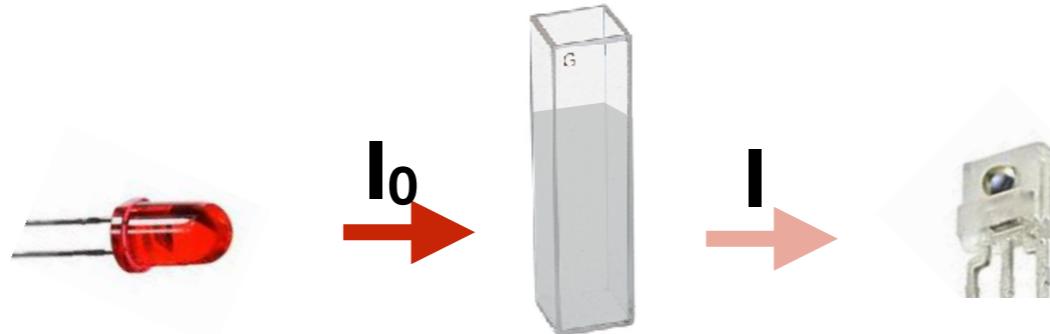


General overview

Spectrophotometer ?



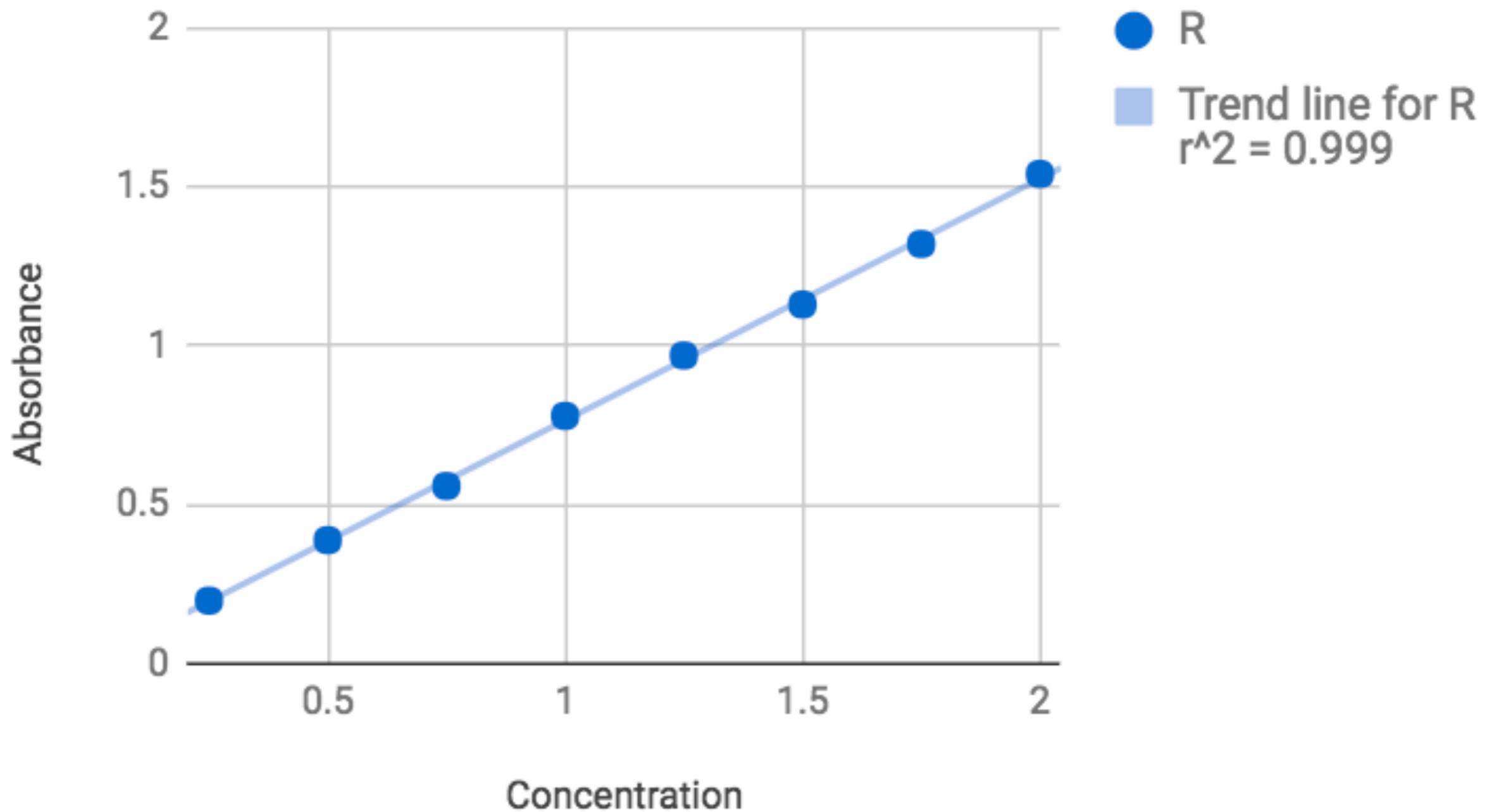
Beer-Lambert law



$$A = - \log (T) = - \log (I / I_0) = \epsilon L c$$

- A: absorbance
- T: transmittance
- I_0 : intensity of the light
- I: intensity of the light after the cell
- L: length of the cell
- c: concentration (M)
- ϵ : molar attenuation coefficient

Experimental results





3. Un spectrophotomètre simple, portable et 100% open source

Le spectrophotomètre est aujourd’hui utilisé pour mesurer l’absorbance d’un échantillon liquide coloré. Cette technique ancestrale a permis à des chimistes de déterminer les propriétés de nombreux liquides. Utilisé couramment, cet outil a néanmoins deux désavantages principaux: son coût, qui le rend inaccessible au grand public, et sa taille, qui ne permet pas de le transporter facilement afin de réaliser des expériences sur le terrain. Dans le cadre du laboratoire de biohacking Hackuarium, situé à UniverCité, à Renens, la famille Patiny, affiliée à l’EPFL, s’est attelée à la fabrication d’un spectrophotomètre 100% open source, de petite taille et alimenté par batterie.



Un spectrophotomètre portable qui détecte les polluants dans les eaux. © DR

Ces deux derniers aspects permettent des applications qui ne sont pas possibles avec des outils commerciaux, notamment dans le domaine environnemental où les mesures sur site sont précieuses. Citons, par exemple, certaines régions de Colombie qui souffrent d’extraction illégale d’or à l’aide de mercure, un polluant extrêmement毒ique. En introduisant un échantillon d’eau dans le dispositif, il est possible de faire un suivi de la pollution en mercure, et d’éviter ainsi des intoxications dues à la contamination de sources d’eau potable.

Principaux secteurs d’applicabilité: chimie, biologie, environnement

Mechanics

Various strategies

3D printing

- ✓ any shape
- ✗ slow
- ✗ not that cheap

Laser cutting

- ✓ fast and cheap
- ✗ limited shapes (2D)

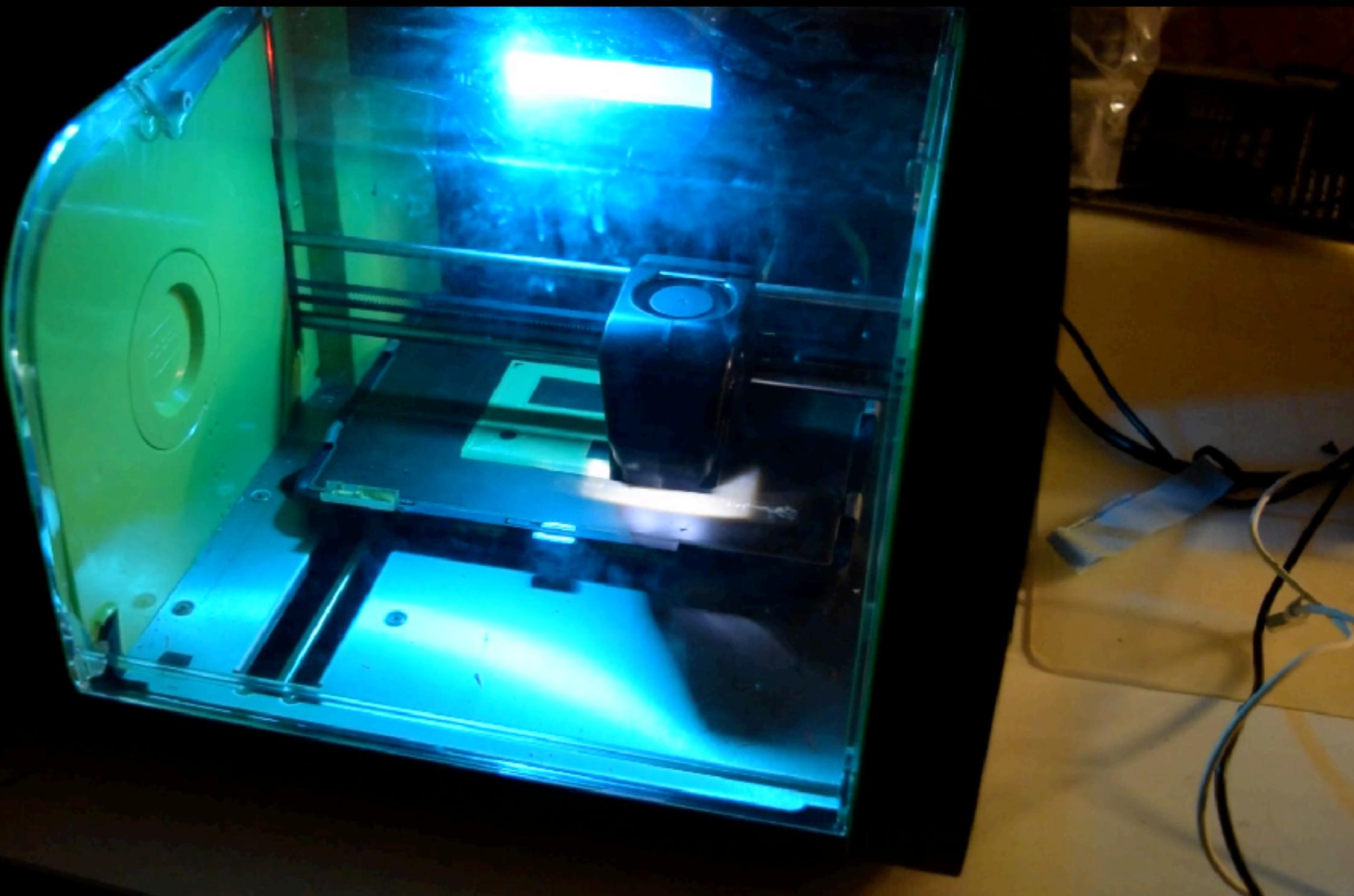
Milling

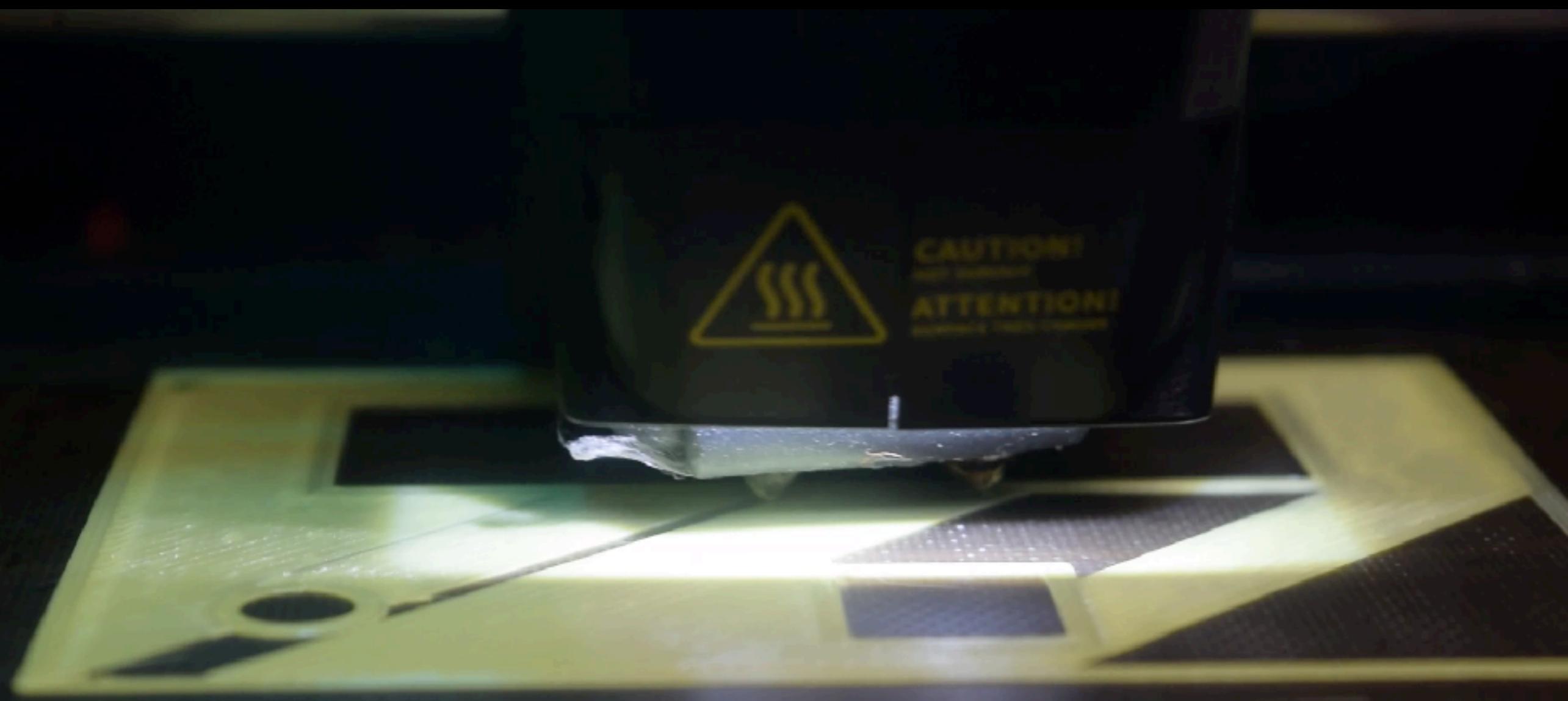
- ✓ perfect quality
- ✗ cost
- ✗ time

Molding

- ✓ cheap for large series
- ✗ setup cost
- ✗ time

3D printing



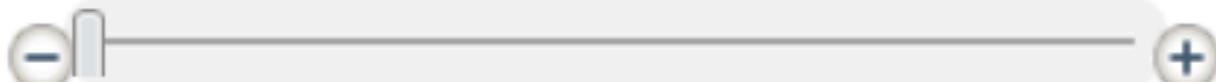




Consumable parts are not covered by this Limited Warranty (these include the printing head, extruder, ThermoSurface™ bed sheet, Bowden tube, filament feed path, filament, accessories (trimming kit, bed wipes, lubricant, tweezers, USB flash drive), power cable, USB cable and on-board microSD card). In particular, the warranty period for the printhead is 500 hours, as defined by the 'Head hours' counter on the chip of the printhead, or 100 days from the date of purchase – whichever is greater. Warranty services may be provided by CEL, an Affiliated/Authorised Reseller, or a third party service provider designated by CEL.



Double click on above image to view full picture



RBX01-S2 - Single Material Dual Nozzle Head- Version 2



Tweet



Like

Be the first of your friends to like this.

Email to a Friend

Be the first to review this product

Availability: In stock.

Quantity Available: 4

Available from:

£149.90

Qty:

ADD TO CART

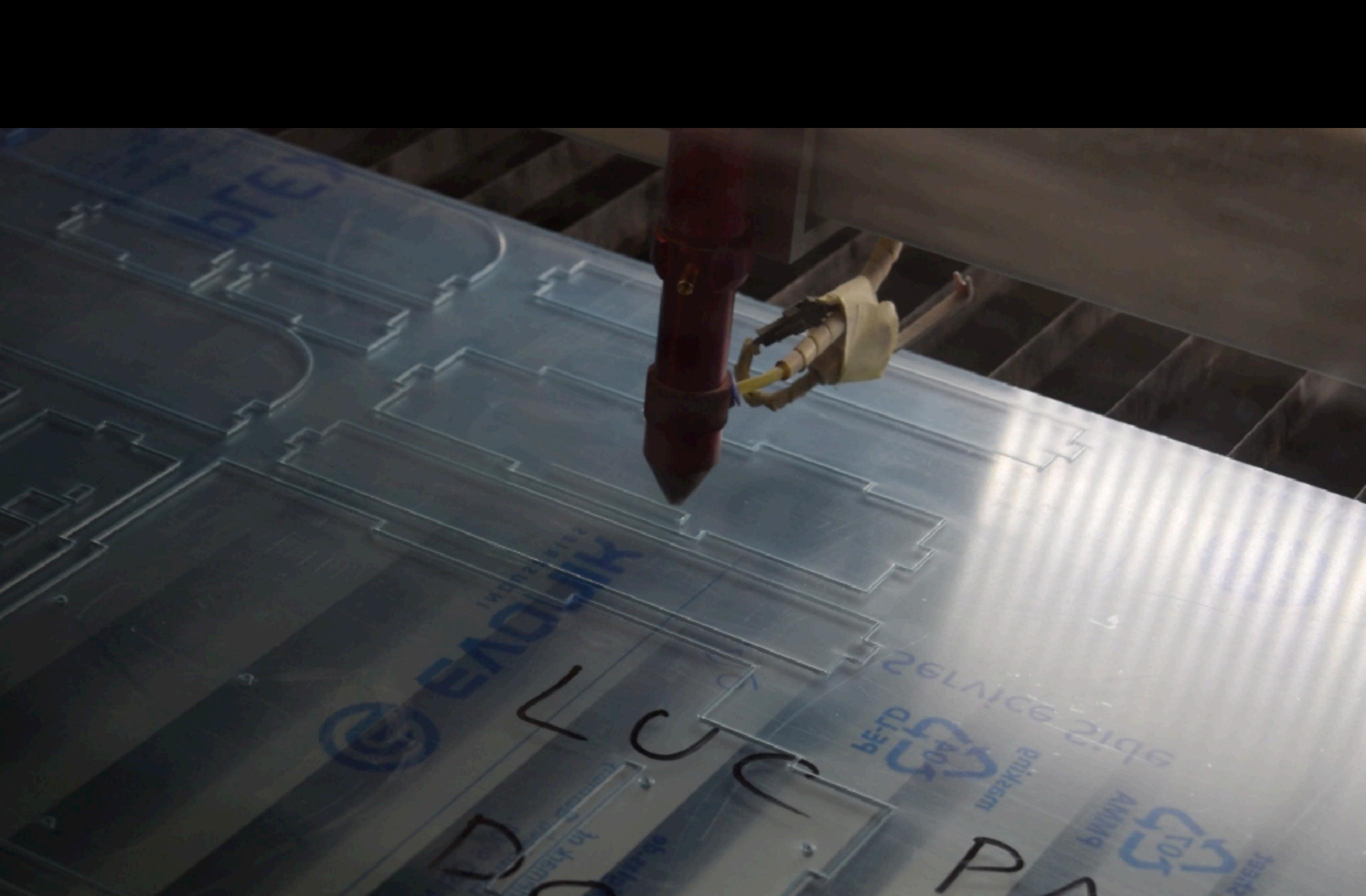
or check out instantly with:

Check out with **PayPal**

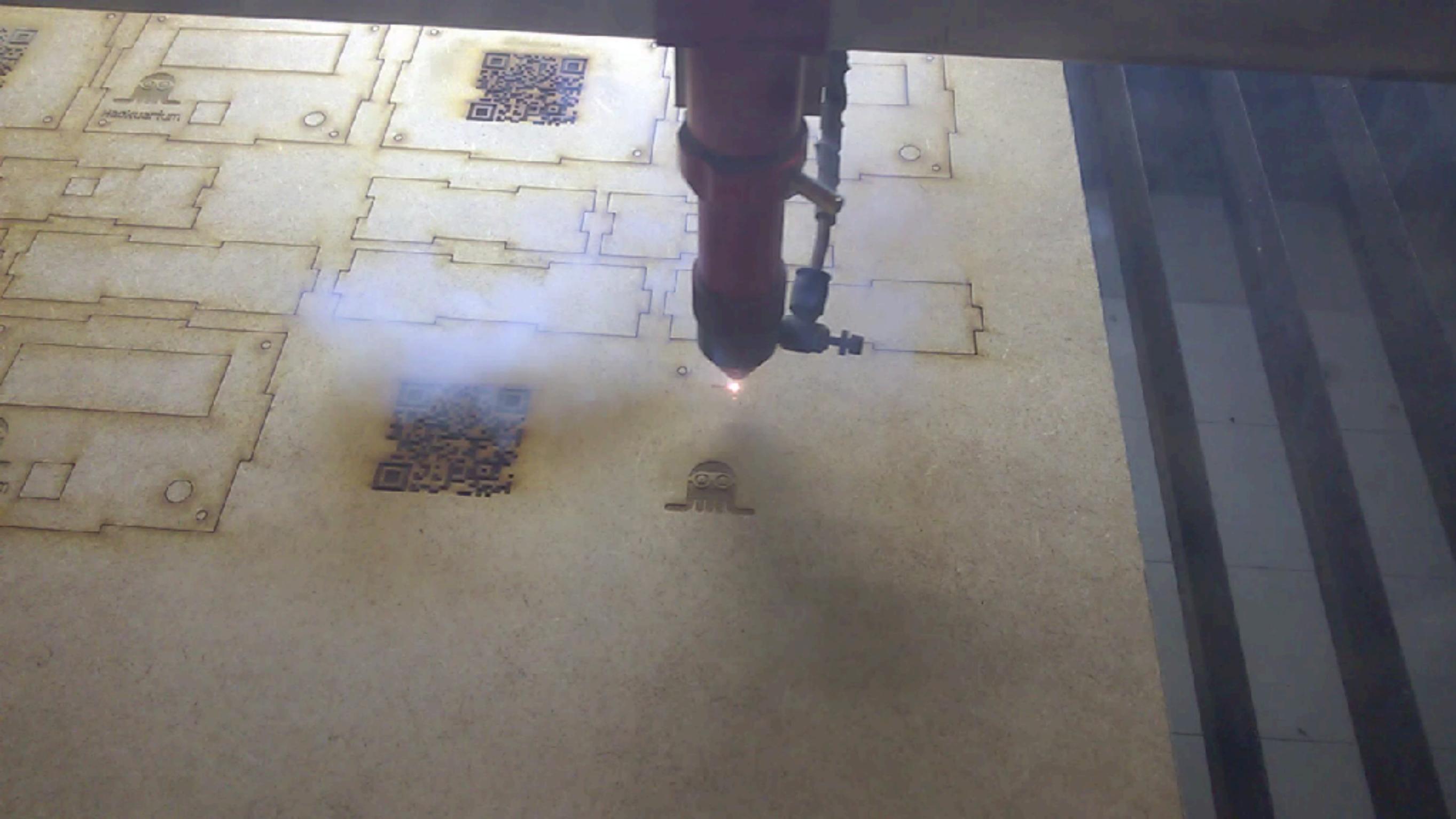
-OR-

PayPal CREDIT

Laser cutting







The cost of laser cutting

- Machine 2000 CHF
- Plexiglas 3mm: 70 CHF / m²
 - <https://roehmschweiz.ch/fr/produits/plaques/plexiglas/gs-allround/>
- MDF 3mm: 10 CHF / m²



Condition: New

Quantity: 1 More than 10 available
51 sold / See feedback

Price: US \$1,999.00

[Buy It Now](#)

[Add to cart](#)

Add to watch list

Add to collection

100% buyer satisfaction

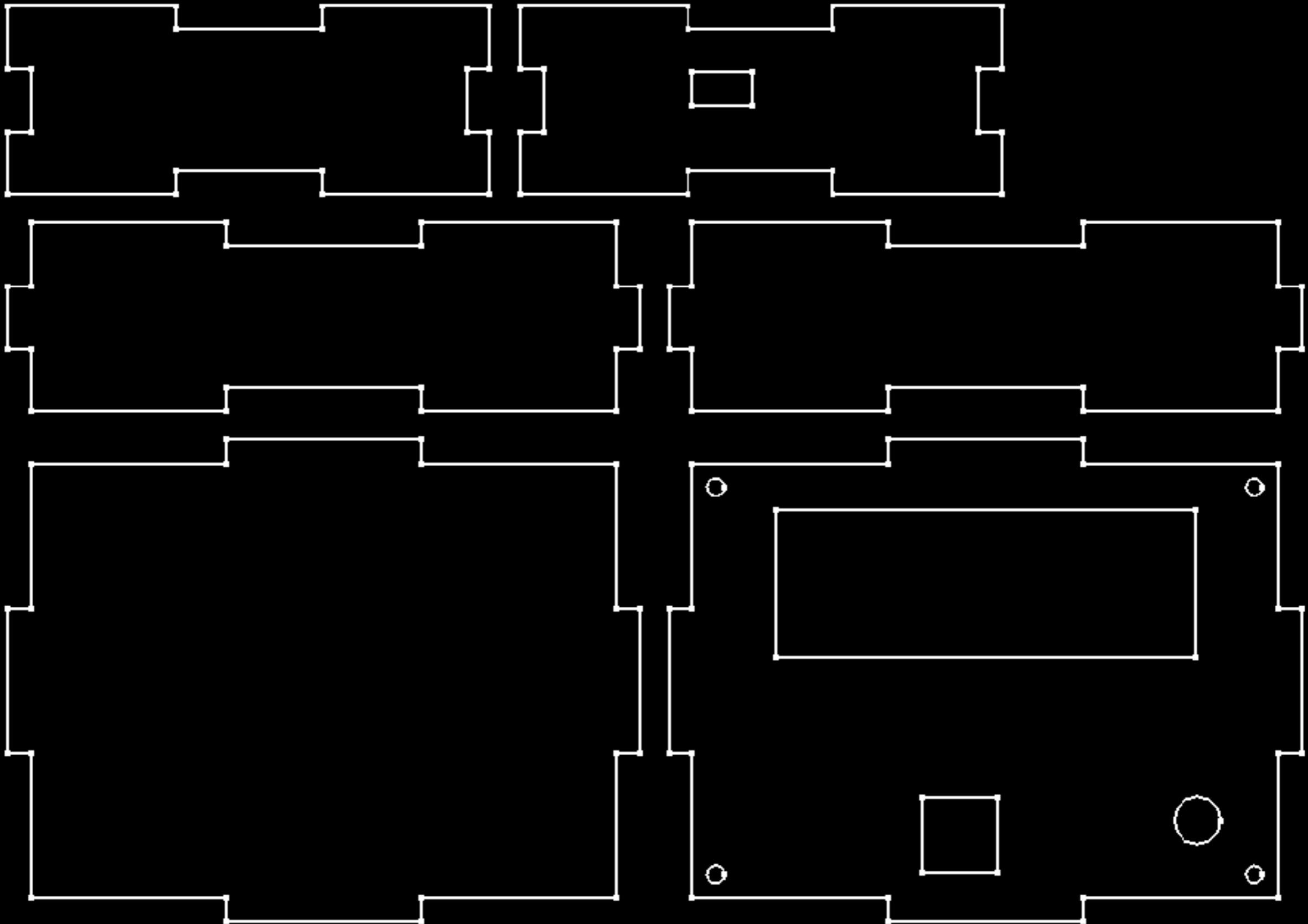
51 sold

More than 76% sold

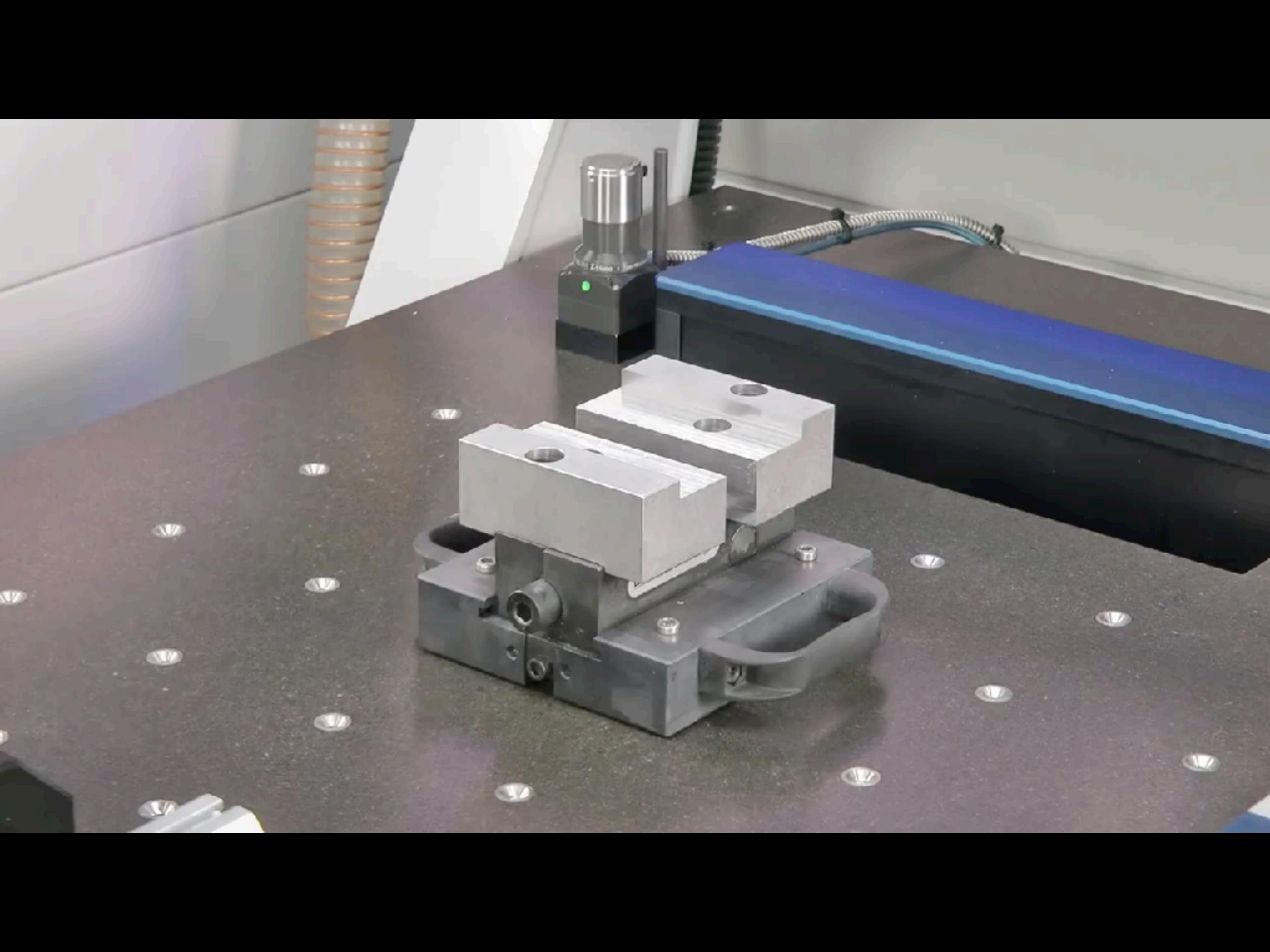
Shipping: FREE Standard International Shipping | [See details](#)
See details about International shipping here.

Item location: CN, China

Ships to: Worldwide



Milling



ZXM Technology Co., Ltd.

Hua feng industry ,Songgang Town, Shengzhen City, Guangdong Province , China

FAX :86-0755-27154623 Mobile :86-13556671200

Contact person :Patrick zhu Website :<http://www.cnc-machiningservices.com>

Mail address :zxm@cnc-machiningservices.com/zxmprecision66@gmail.com

Skype :Patrick85858 QQ:597145002

Quotation List

Date :Oct/24/2017

Products name (Drawings NO)	Material	Surface treatment	Quantity (pcs)	unit price (usd)	total price	shipping
Box (include two parts)	AL-5052	Black anodized	20	\$36. 20	\$724. 00	DHL
			50	\$33. 00	\$1, 650. 00	
			100	\$31. 00	\$3, 100. 00	
Total value						

NOTES:

USD:RMB=1.0:6.5

1. This price is DOOR TO DOOR PRICE and keeps valid for 30 days .
2. Delivery is 20-25days upon confirmation of purchasing Oder and down payment
3. The payment term is 100% deposit by T/T.

Molding

Molding

<http://www.emold.net/>

Part Information

Product Size : 10.00 cm * 8.00 cm * 2.50 cm

Cavity : 1

Life : <5000

Plastic : PTFE (teflon)

Mold Price Calculation

Mold Frame : 121.21 USD

Mold Core : 90.91 USD, p20 China Made

Copper Electrode : 90.91 USD

Total material : 303 USD

Production Cost : 400 USD

Hot Runner : 0.0 USD

Management Cost : 20%

Tax : 68.0 USD

Total Mold Price : 912 USD

Product Price Calculation

Material Unit Price : 10.61 USD/kg

Product Material Cost : 0.53 USD

Production Speed : 60 seconds

Chosen Injection Machine : 600 Ton

Production Cost : 0.48 USD

Profit : 10%

Tax : 10%

Product weight : 0.05 kg

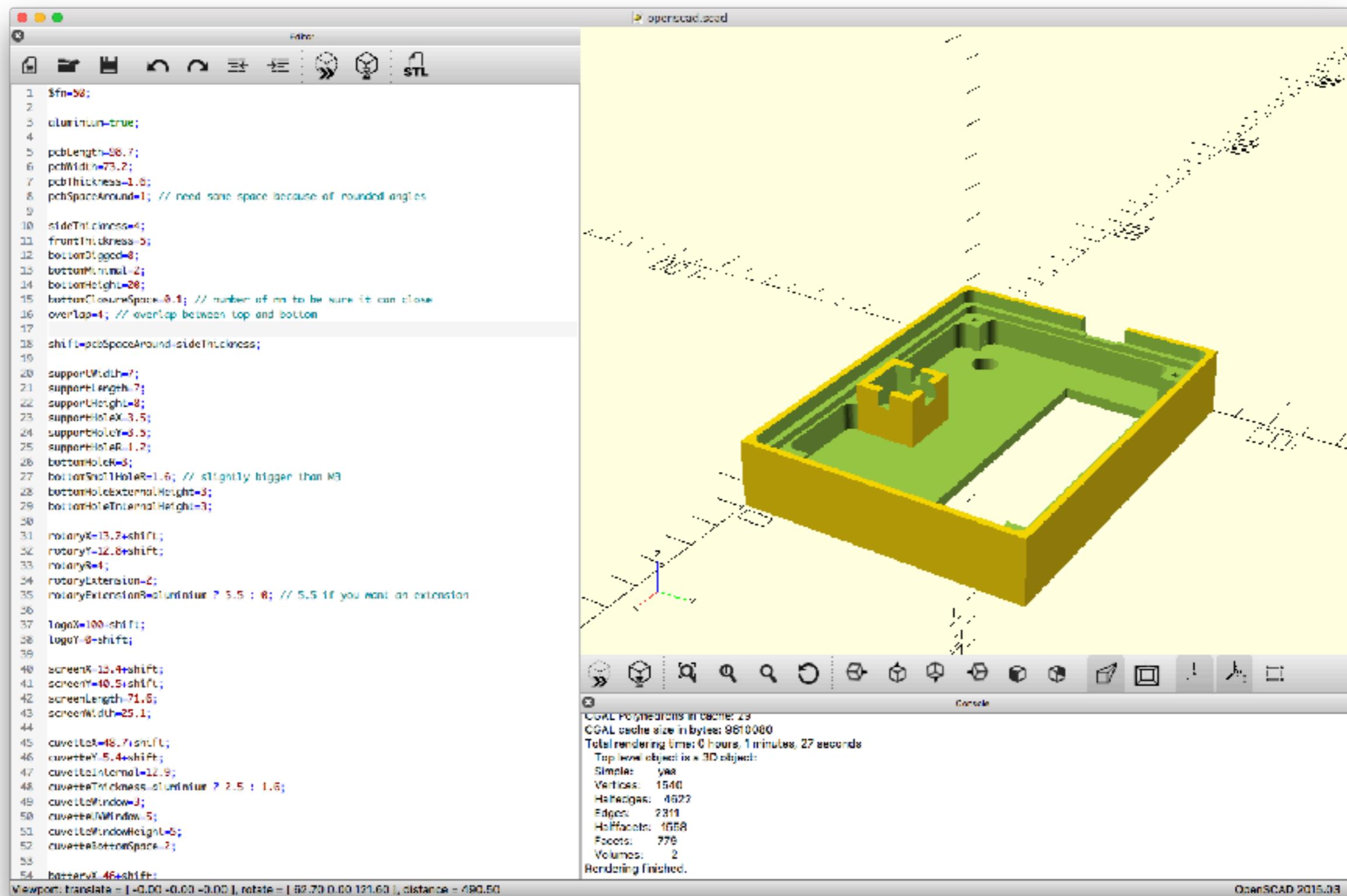
Product Unit Price : 1.25 USD (Note)

Generating the files

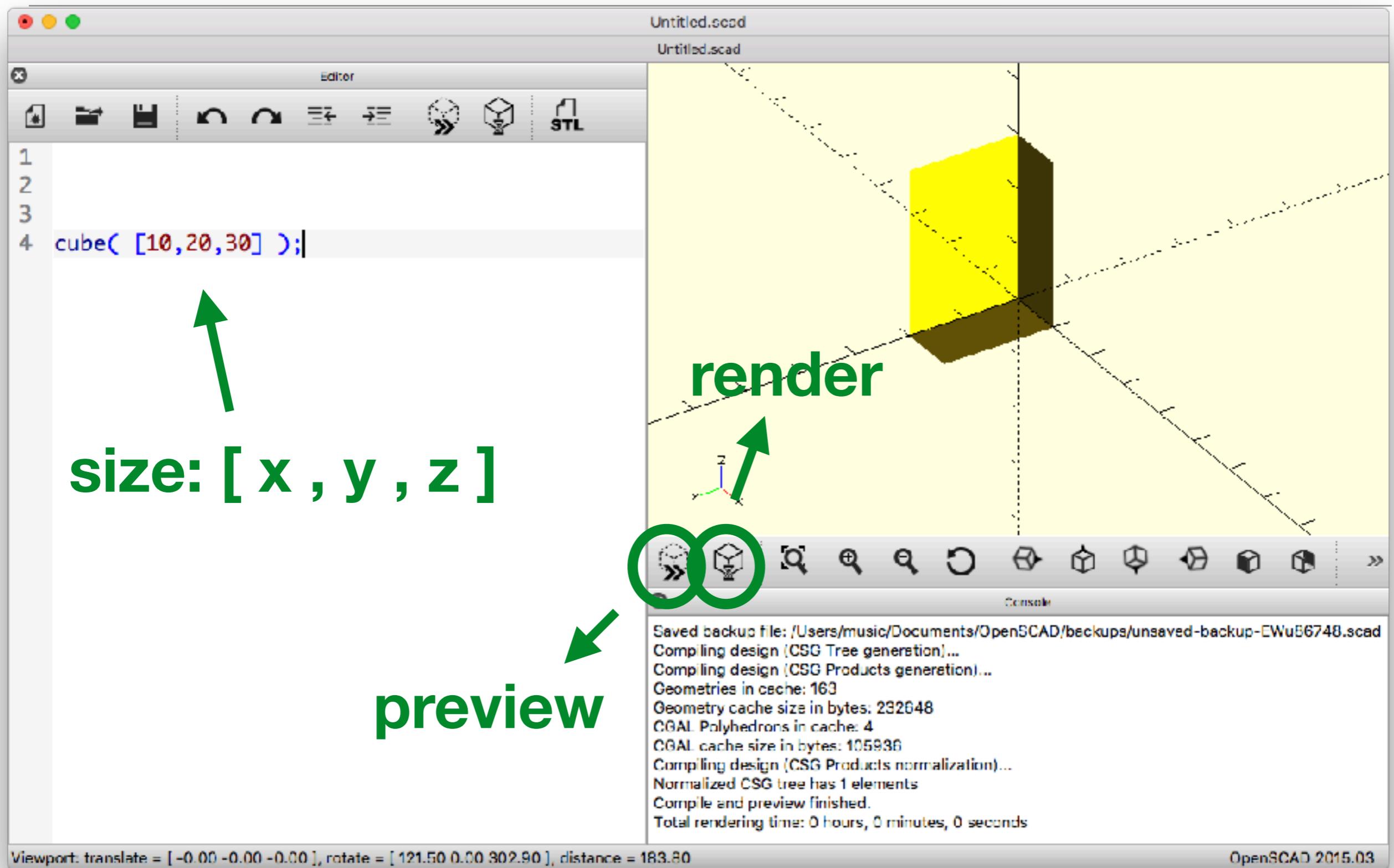
Open-source:

- FreeCAD
- OpenSCAD

OpenSCAD



Creating a 'cube'



More complex example

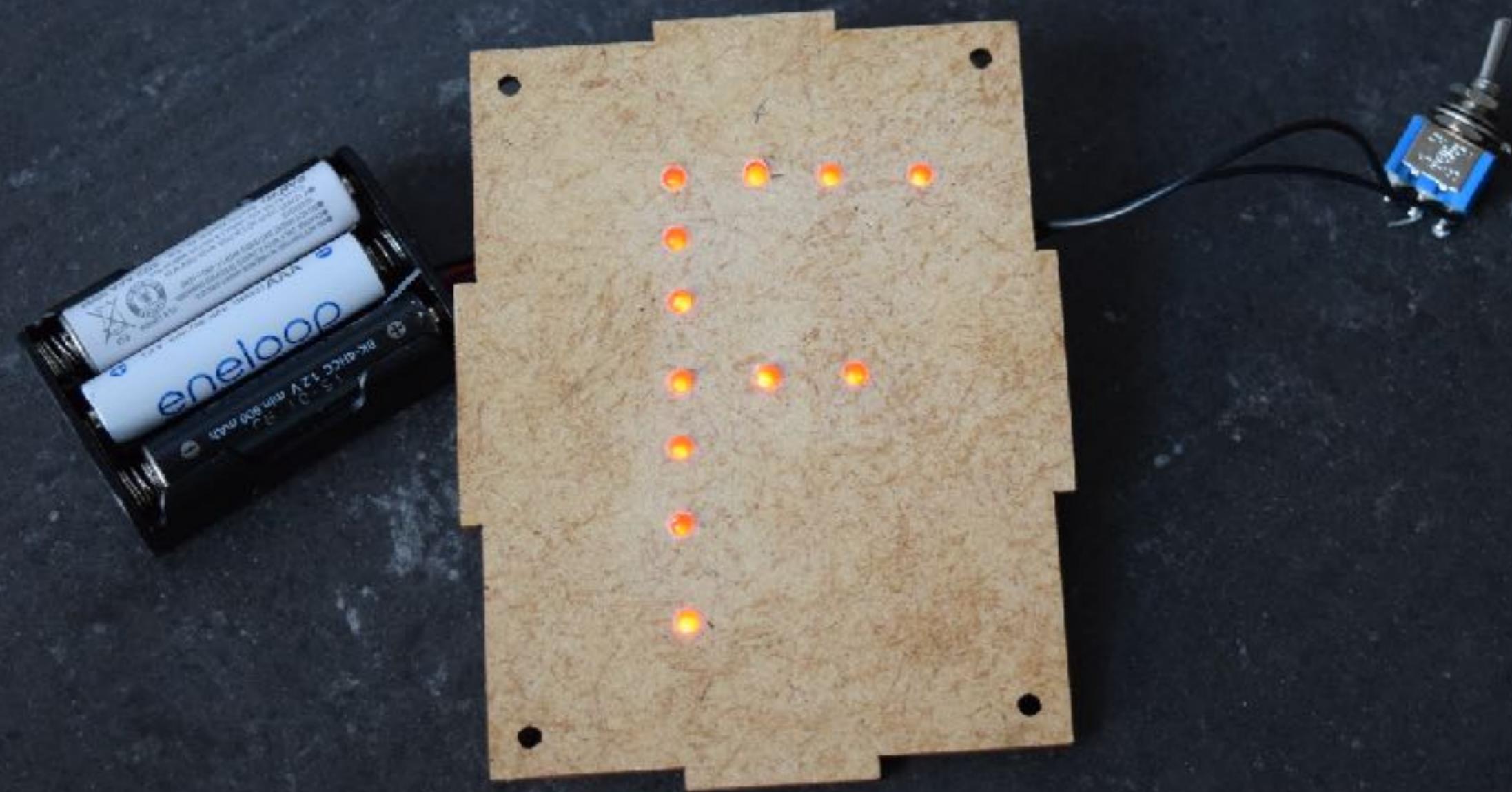
The screenshot shows the OpenSCAD application interface. The top bar displays the file name "Untitled.scad". The left side features a code editor with the following SCAD code:

```
1
2
3
4 cube( [10,20,30] );
5
6 cylinder( r=10, h=20 );
7
8 translate( [25, 0, 0] )
9     sphere( r=10 );
10
11 translate ( [0, -40, 0])
12 difference() {
13     cube( [20,20,20] );
14     cylinder( r=10, h=20);
15 }
```

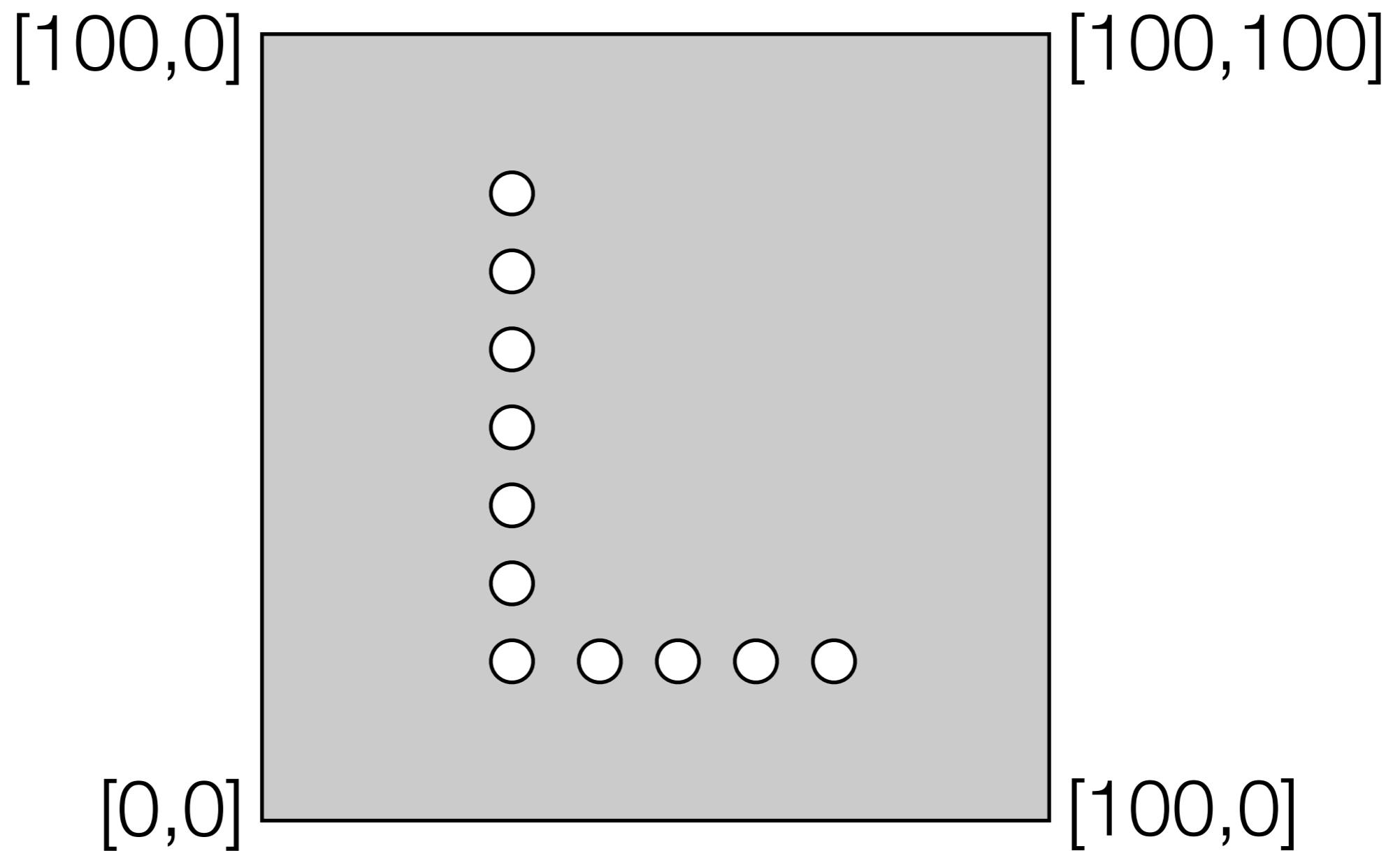
The main workspace displays a 3D rendering of the generated model, which consists of several interconnected geometric shapes: a large yellow cube, a smaller yellow cylinder, a yellow sphere, and a yellow rectangular prism. The bottom right corner of the model has a green gradient. The bottom bar contains a "Console" tab with the following output:

```
CGAL Polyhedrons in cache: 8
CGAL cache size in bytes: 2509656
Total rendering time: 0 hours, 0 minutes, 2 seconds
Top level object is a 3D object:
Simple: yes
Vertices: 529
Halfedges: 2762
Edges: 1381
Halffaces: 1716
Facets: 858
Volumes: 1
Rendering finished.
```

At the very bottom, status bars show "Viewport: translate = [-0.00 -0.00 -0.00], rotate = [21.40 0.00 325.30], distance = 164.84" and "OpenSCAD 2015.03".



Grid to define the holes



box-leds.scad

box-leds.scad

Editor

File Edit View Insert Tools Help

```
1 include <./box.scad>
2 box(
3     width = 100,
4     height = 100,
5     depth = 40,
6     thickness = 4,
7     finger_width = 20,
8     assemble = true,
9     labels = true,
10    open = false,
11    holes_left = [
12        [20,40]
13    ],
14    hole_left_dia = 6,
15    spacing = 3,
16    holes_front = [
17        [30,80],
18        [30,70],
19        [30,60],
20        [30,50],
21        [30,40],
22        [30,30],
23        [30,20],
24        [40,20],
25        [50,20],
26        [60,20],
27        [70,20]
28    ],
29    hole_front_dia = 5,
30    only_front_holes = true
31 );
32 
```

TOP

Front

z

x

Console

```
Compiling design (CSG Tree generation)...
Compiling design (CSG Products generation)...
Geometries in cache: 226
Geometry cache size in bytes: 891416
CGAL Polyhedrons in cache: 12
CGAL cache size in bytes: 4604376
Compiling design (CSG Products normalization)...
Normalized CSG tree has 12 elements
Compile and preview finished.
Total rendering time: 0 hours, 0 minutes, 0 seconds
```

Viewports translate = [35.57 69.73 31.17], rotate = [82.50 0.00 336.50], distance = 366.70

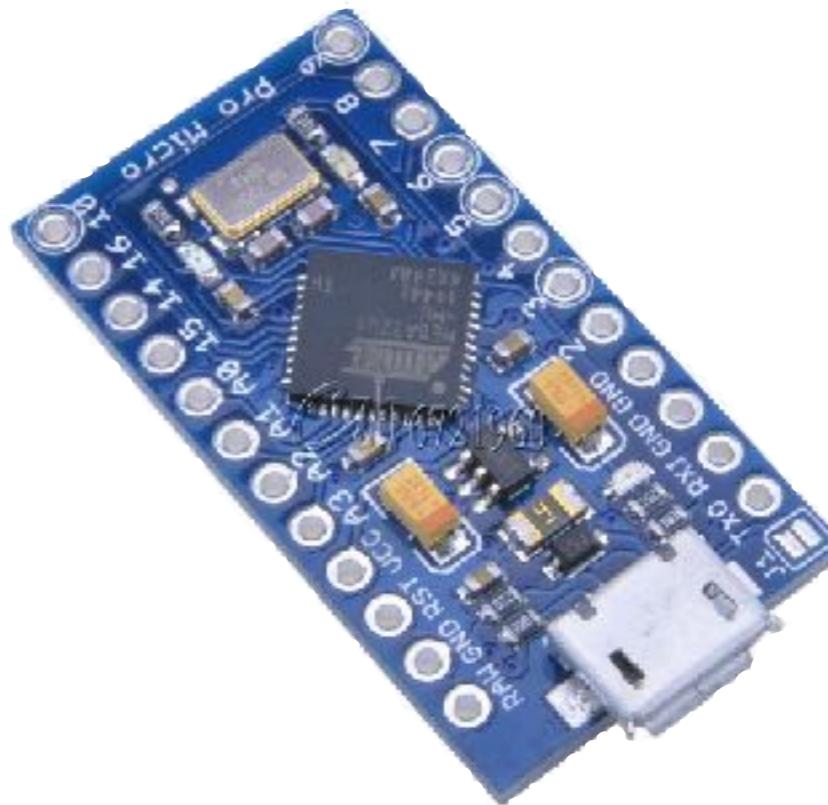
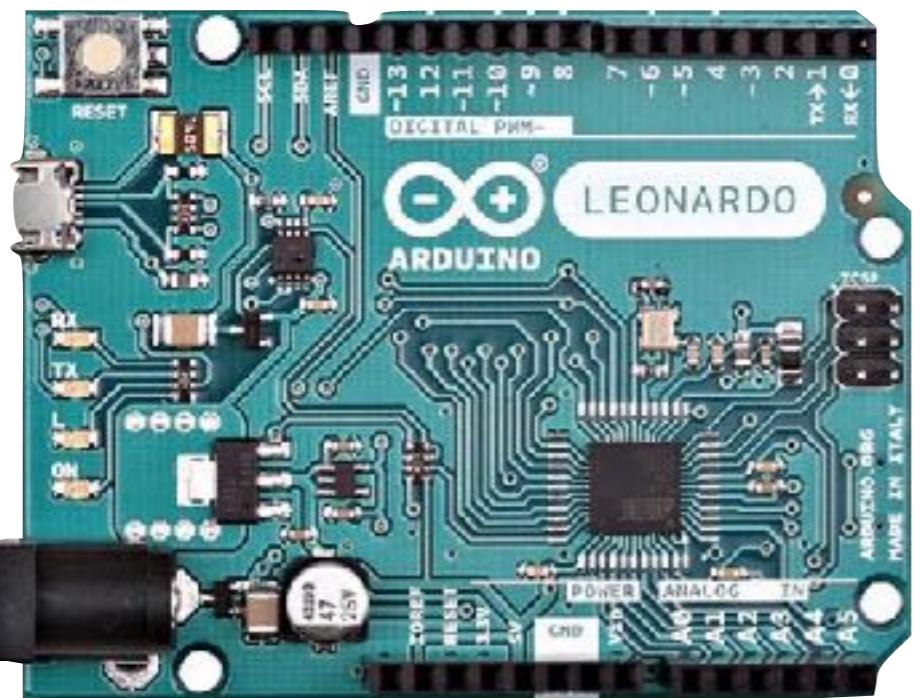
OpenSCAD 2015.03

Electronics

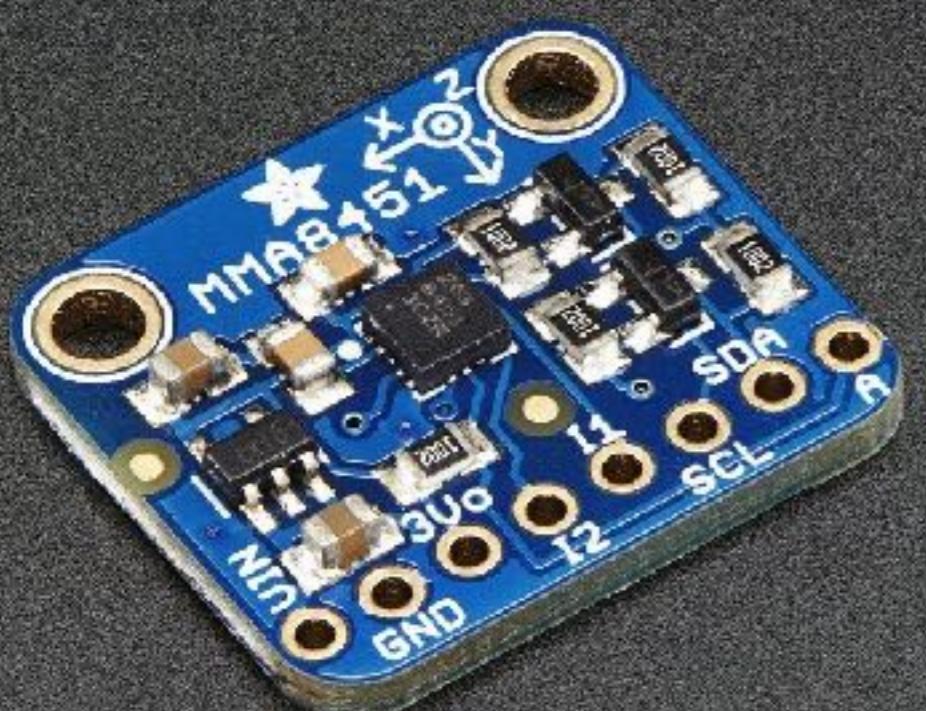
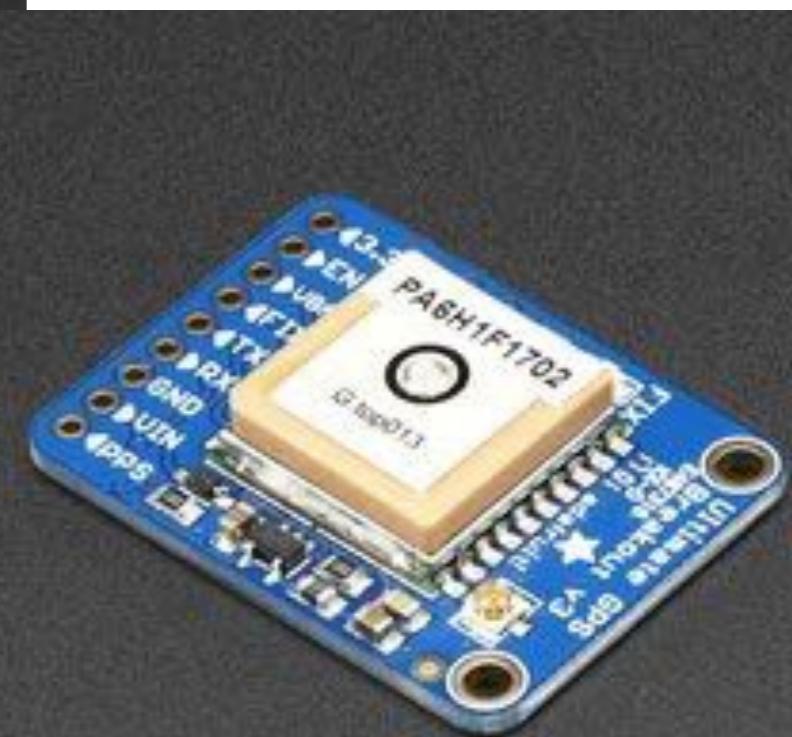
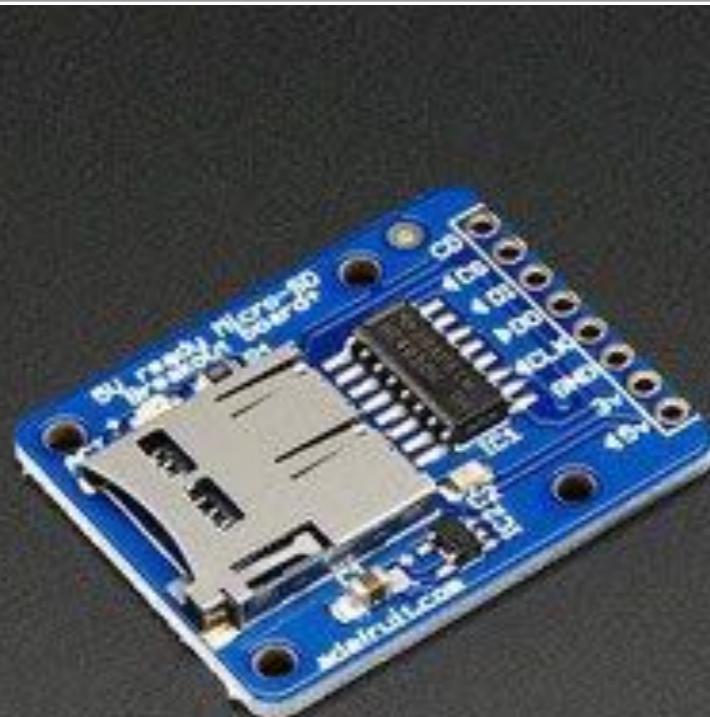
Arduino ...

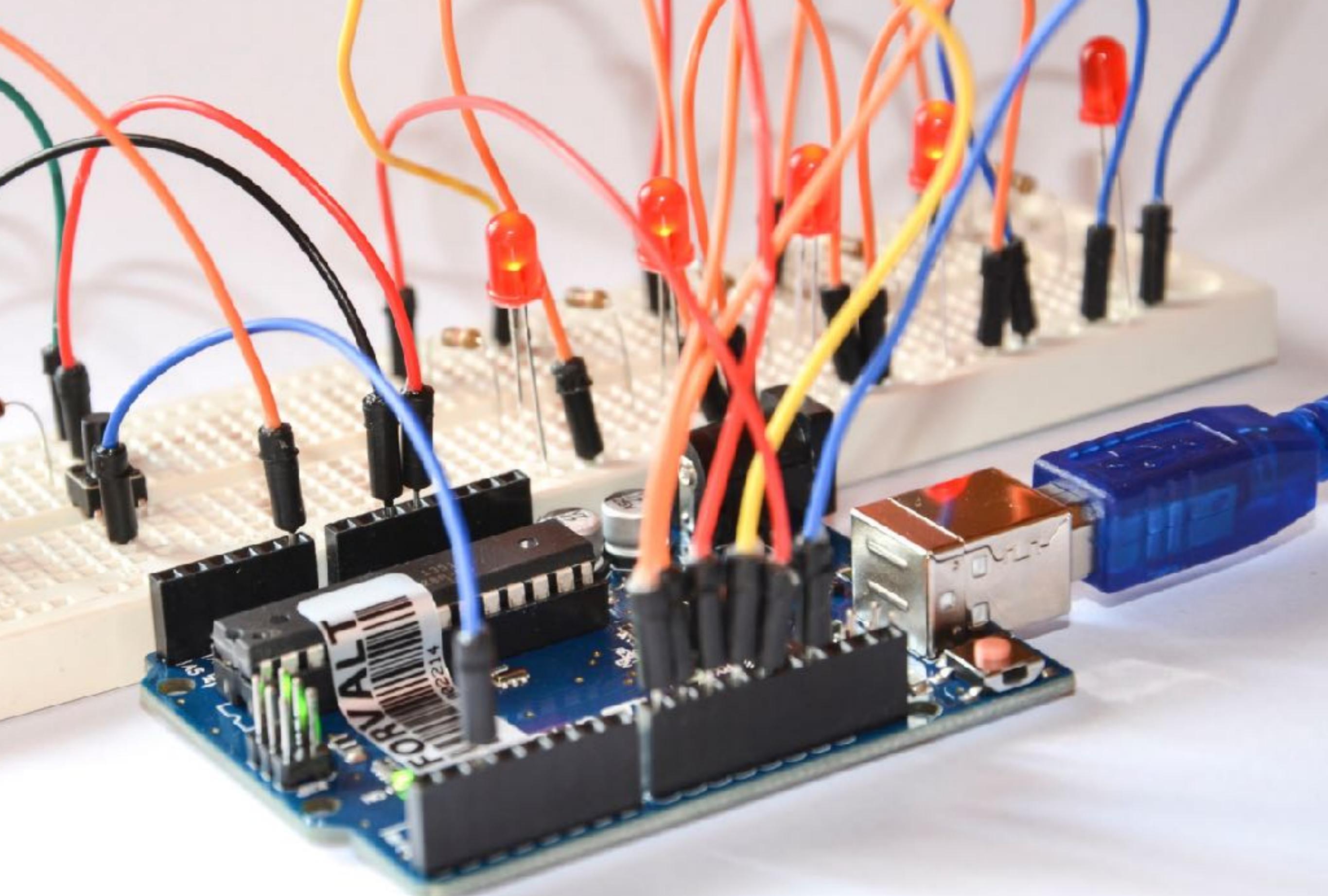
Classical approach

Arduino platform

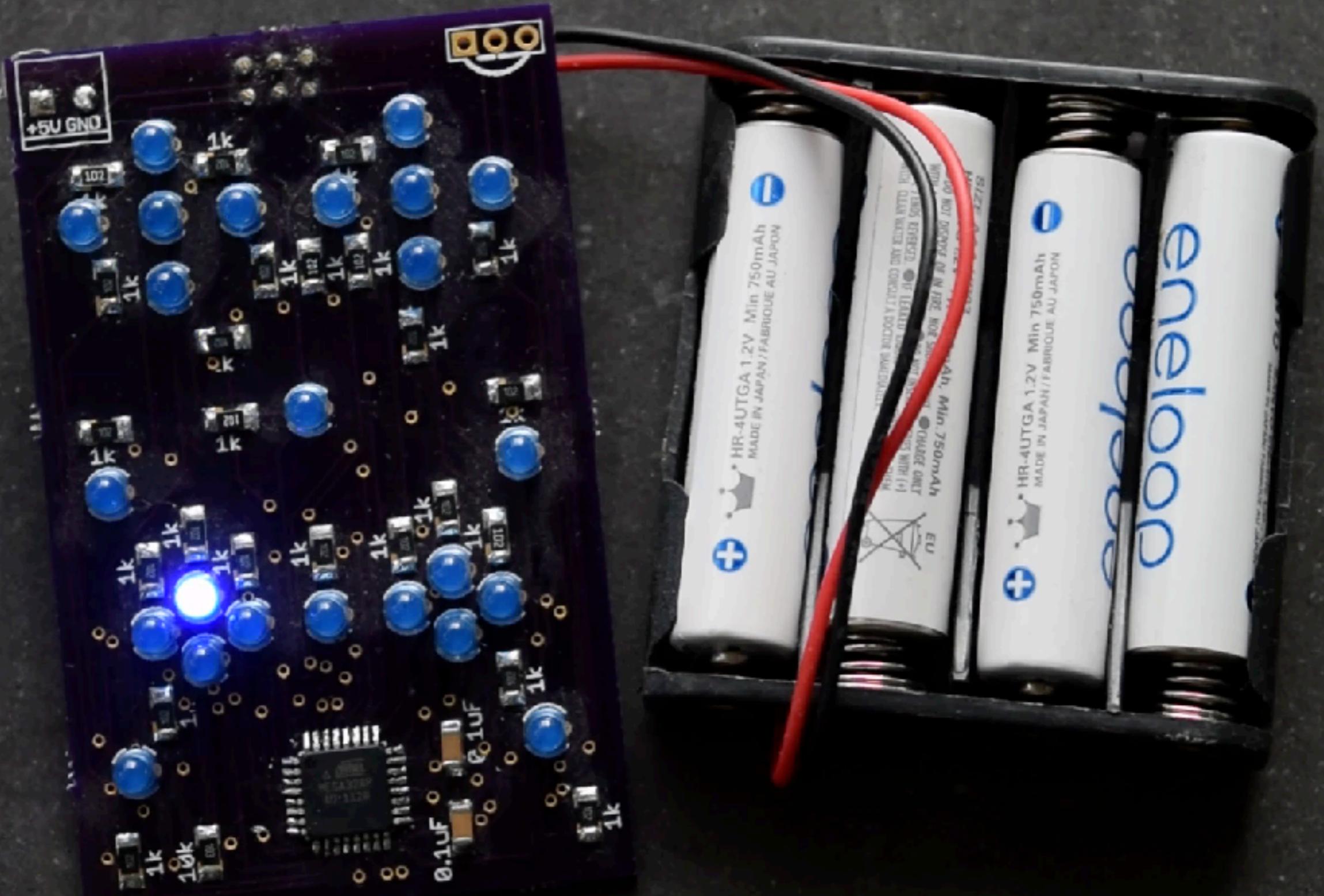


<https://www.adafruit.com/?q=breakout>



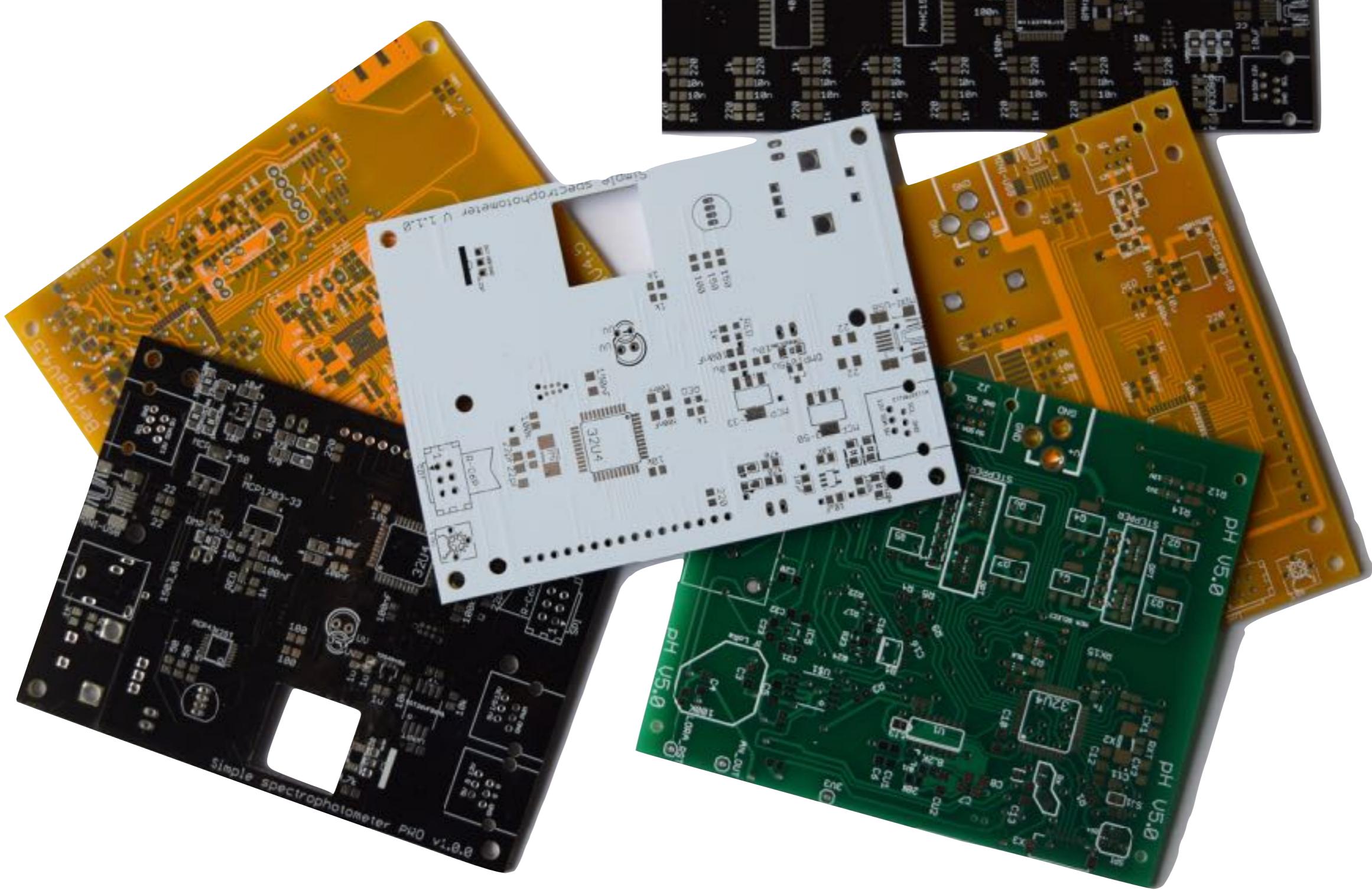


**Can we make our own
Arduino ?**



Making your own PCB

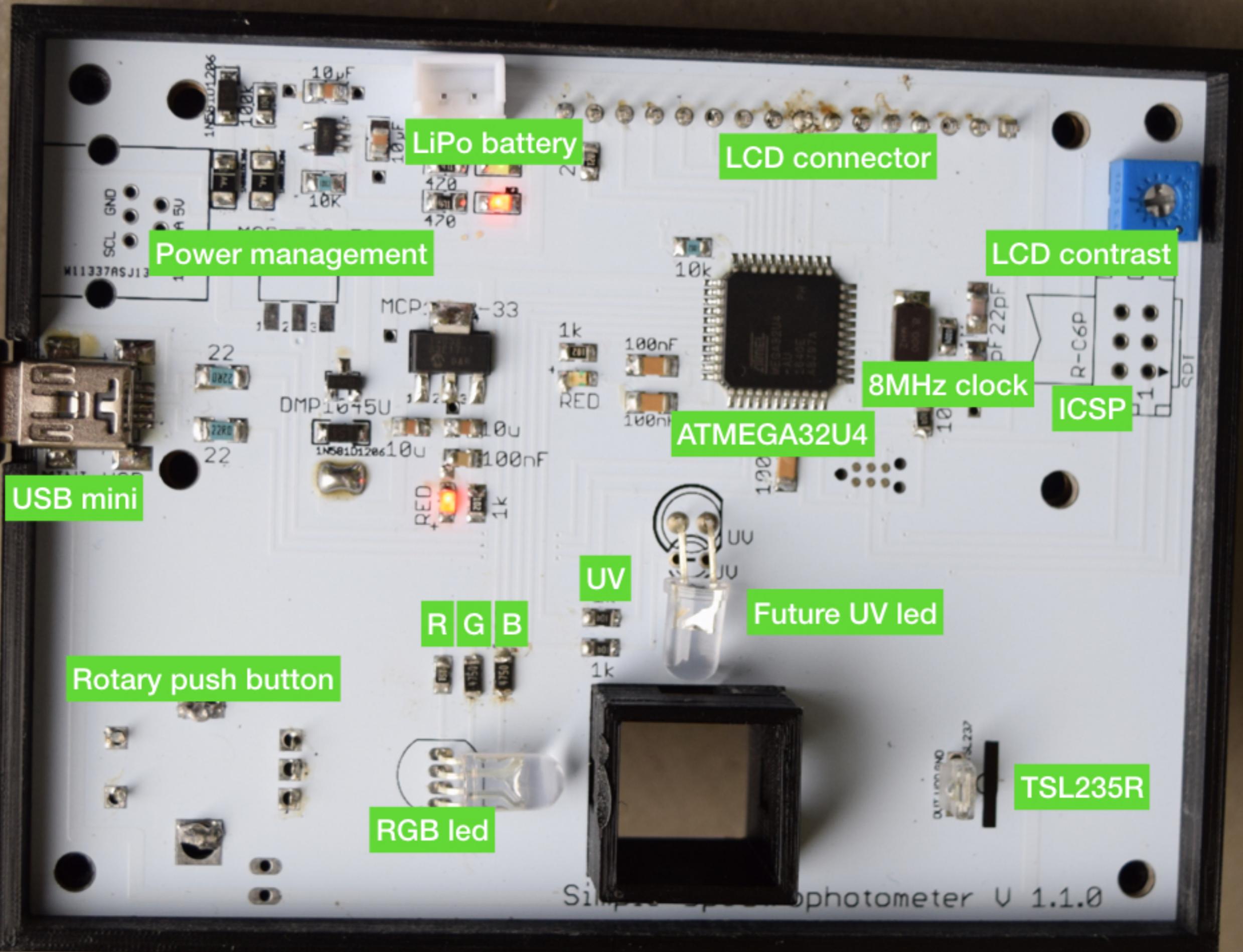
www.pcbway.com - www.seedstudio.com



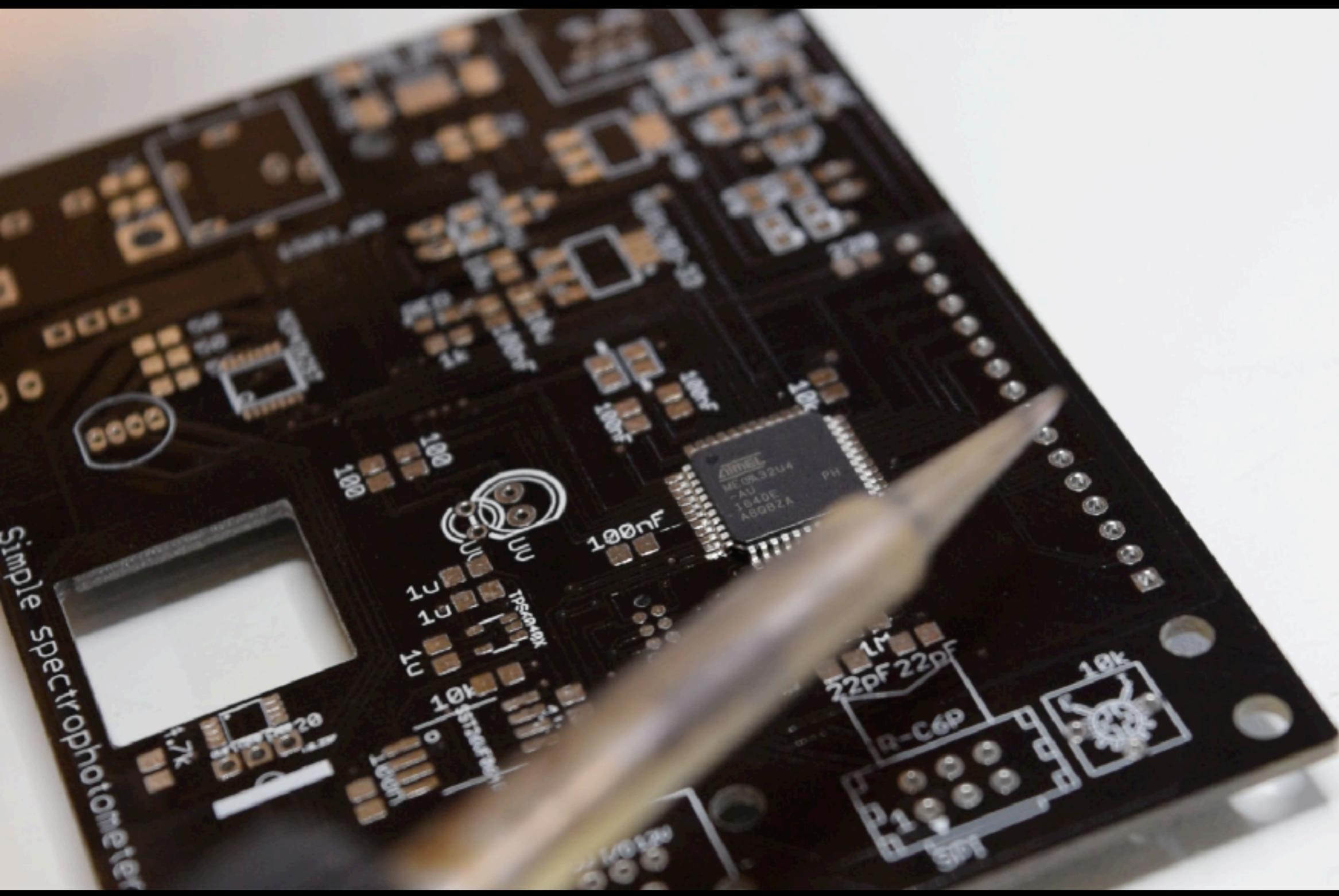
PCB production

- \$5 for 5 to 10 PCBs 10x10cm
- + shipping ... \$10 to \$25
- Numerous suppliers
 - <http://www.pcbway.com> (currently my preferred one)
 - <http://www.seedstudio.com>
 - <http://www.elecrow.com>
 - <https://oshpark.com> - \$5 for 3 per square inch
- One week !

Soldering the PCB



Simple spectrophotometer



PCBA

Printed Circuit Board Assembly

www.elecrow.com

- **Free components list**
 - <https://www.elecrow.com/pcb-assembly-p-366.html>
 - 120 SMD capacitors
 - 235 SMD resistors
- **Provider:** <https://lcsc.com/>
- **In Eagle:**
 - 'attr', add LCSC Part # (or free components)
 - 'run ULP ➔ bom', export as CSV
 - 'export ➔ mount SMD' : export .mnb and .mnt

www.elecrow.com

For PCB fabricate		Dimension/cm	Thickness/mm	Surface Finished	Solder Mask	Qty	Quotation (\$)
Project Name	Layers	10*10	1.6	HASL leadfree	Green	20 100	\$26.90 \$123.78
Stencil for assembly						1	\$18.00
						20pcs Total with stencil:	\$44.90
						100pcs Total with stencil:	\$141.78

For PCB Assembly							
Project Name	Pads	Qty	Price	Qty of Boards	Quotation	Remark	
simple-spectro	SMT	135	0.030	20	\$81.00	50% discount	
				100	\$202.50		
				20pcs Total : 100pcs Total :	\$81.00 \$202.50		

Engineer Start		
20pcs Total :	\$10.00	
100pcs Total :	\$0.00	Free

Components purchased by Eelcrow	Remark
20pcsTotal :	\$149.800
100pcsTotal :	\$623.00

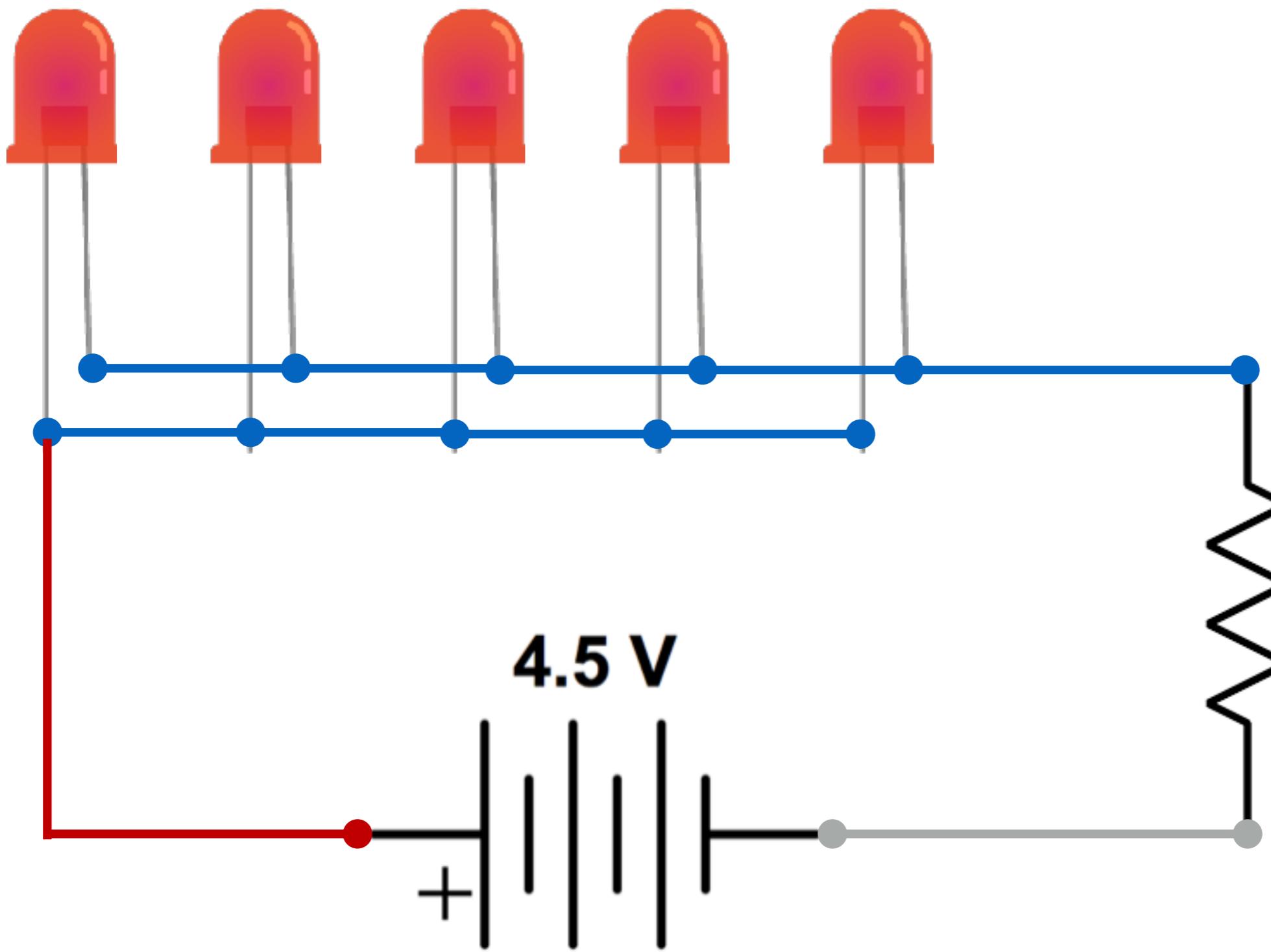
Shipping					
Products	Shipping Method	Weight(g)	Quotation	Remark	
20PCBAs	DHL	2500.00	\$29.40		
100PCBAs		8000.00	\$71.35		
		20pcs Total :	\$29.40		
		100pcs Total :	\$71.35		

20pcs Total Quotation (\$):

100pcs Total Quotation(\$):



Small exercise



Conclusions

What did we learn ?

- **Anybody can go quickly from an idea to an advanced prototype**
 - 3D printing
 - Laser cutting
 - Cheap PCB prototyping
 - PCB assembly
- **With open-source software !**

Hackuarium - Hackerspaces

- **Allows to learn quickly and efficiently**
- **Cheap: you don't need the highest end equipment to learn**
- **Scientific rigour: most of us have a scientific background**
- **Win - win situation with companies**
 - access to a pool of interesting and passionated people
 - team building, open the mind of company employees

Next for the spectro ?

- **Small production of 50 for swiss schools**
- **Looking for funding to offer spectrophotometers to developing countries**
- **Can organise a one day working 'build your spectrophotometer'**



Microcontroller : ATMEGA32U4

- 32 kbytes of programmable flash memory
- 2.5 kbytes SRAM (Static Random Access Memory)
- 1 kbytes EEPROM (Electrically Erasable Programmable Read Only Memory)
- Operating voltage: 2.7V to 5.5V
- 18 pins 2.7V I_{OL} (max 4.5V) PDI
- 16 I/O, 12 x 10bit ADC
- USART, I2C, SPI, IRIN, IROUT
- 2 x PWM 16 bit, 8 x PWM 10 bits

4 CHP









