# Can We Use a Computer CD Drive to Pattern Future Nanotechnology?

M. T. Walker[1] & M. T. Cole[1*]

## Introduction

Since its invention, photolithography has become essential in the research and manufacture of electronics. Traditional methods such as using wafers are costly. An alternative to wafers is using a direct write laser system, but these are expensive too. Customers are charged hourly rates; a figure from the United States show about $126 per hour [1]. There is a need for the Vacuum Nano Electronics Group to build a low-cost alternative, which this project proposes to do. To be considered successful the device must: use a laser to pattern a photoresist, have a sturdy enclosure that shields users from the laser light, interface with a computer to receive patterning signals, have an extensible design which another student can take and improve upon, and bring costs down compared to a commercial direct write laser system. Integration of hacked Commercial Off-The-Shelf (COTS) electrical components will help reduce costs.

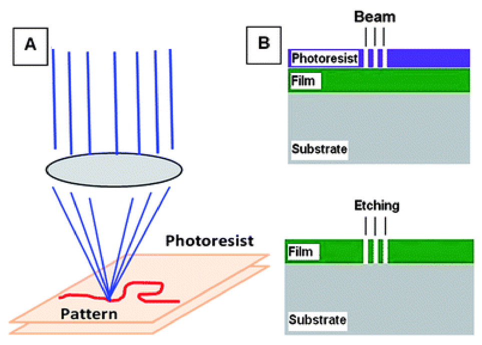



**Figure 1.** . Demonstration of the photolithography process using a positive photoresist which is etched away by solvent when exposed to the laser. A direct write laser system is used so a mask is not required. Diagram from [2].

## Enclosure Design

The initial enclosure design, Figure 3a, provided a foundation on which to iterate. Slot joints and bolts are used in conjunction to increase rigidity. The first design contained room for two stepper motors to control X and Y movement, but to focus the laser movement in the Z direction is also required. Additionally, a top cover is needed to enclose the PCB. These changes are implemented in the final design, Figure 3b. Ventilation holes are also necessary, and an inside wall is used to offset the ventilation holes to the outside to save exposing the user to the laser light.

(a)

(b)

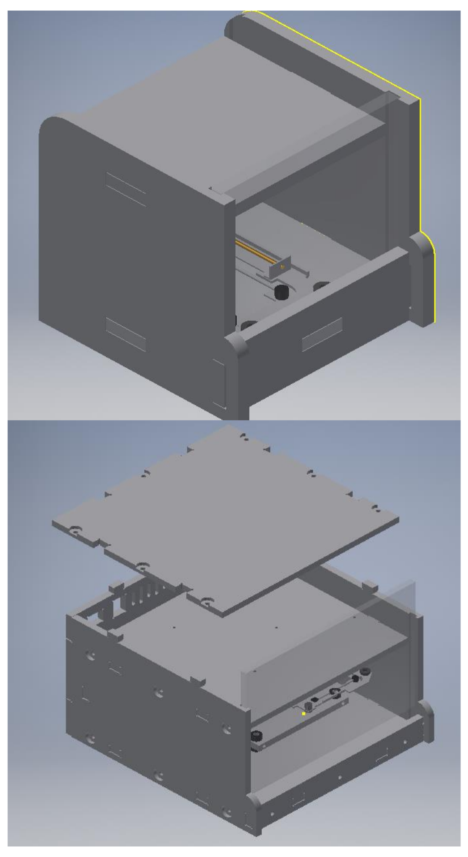


**Figure 3.** (a) First enclosure design. The main chamber is only big enough for two inches of movement, and the PCB sits on the top exposed.
(b) Final enclosure design with the lid raised. Includes mounting points and ventilation holes, and an inside wall for cable management

## Existing Solutions Analysis

Several existing engineering solutions may provide a starting point for this project. LightScribe, Figure 2a, was a system developed to etch graphics into writeable optical disks. It never saw a release with a Blu-ray laser, the 405 nm wavelength required to pattern photosensitive film, so it does not remain a viable start point for the project.
Another proposed option could be to 'hack' an existing Blu-ray drive via hardware or software methods. Finally, hobbyist laser engraving projects [3] may provide the foundation for a successful project. These typically make use of stepper motors recovered from electronics, and a microcontroller to manage all of the electronics, Figure 2b.. As this is able to match the project aims most successfully, this is the proposed design framework used.

(a) (b)

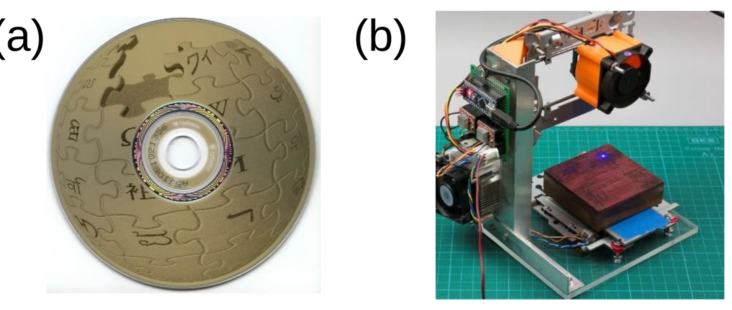


**Figure 2.** (a) The Wikipedia logo etched onto a LightScribe disk. The disk is patterned with a standard DVD laser, the barcode inside of the disk is used to orient the disk. Image from [4].
(b) A hobbyist project which uses two stepper motors which move in the Cartesian coordinate space. An Arduino controls the electronics and receives g-codes to control the patterning from a computer. Image from [3].

## PCB Design

A PCB is required to control the +12 V components (such as the laser diode), and to interface between the microcontroller (Arduino Mega 2560) and CNC Shield V3 board. The CNC Shield controls stepper motors to perform movement of the laser. The third and final iteration of the PCB, Figure 4, implements the laser driver circuit and the Arduino/CNC interface. Many of the redundant pins on the Arduino are exposed on the PCB as headers to ensure an extensible design.

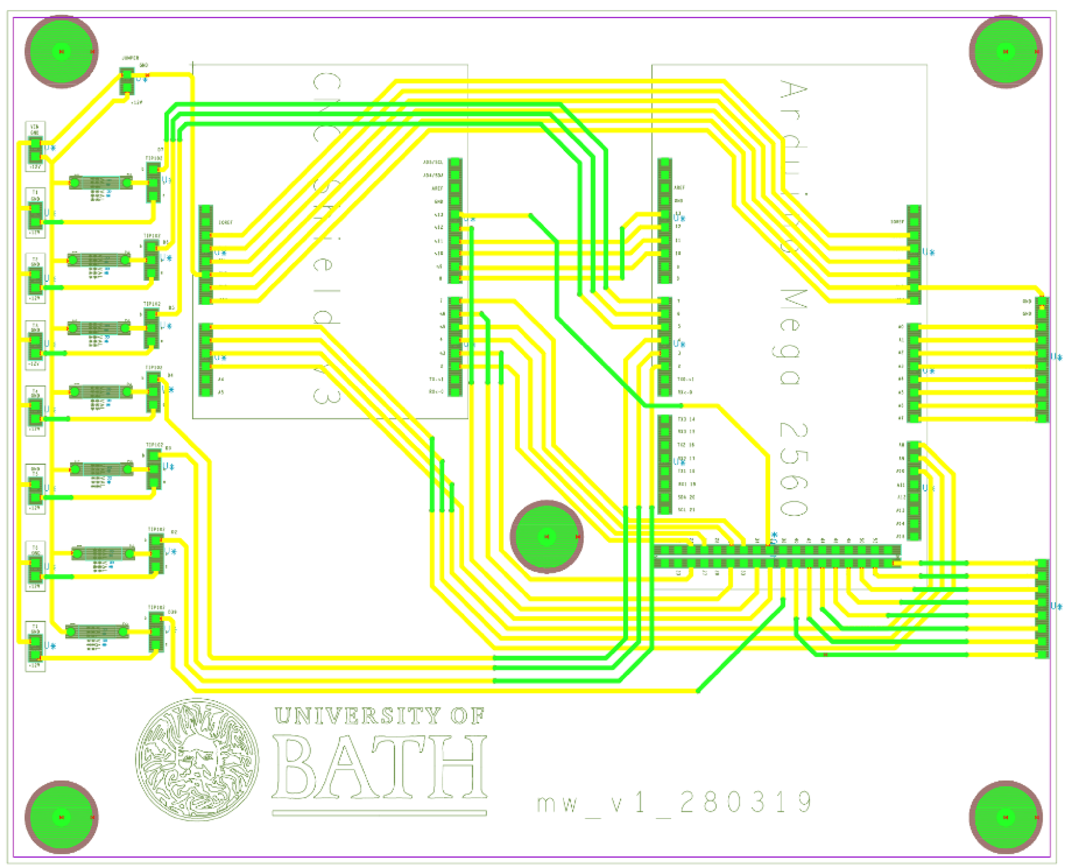
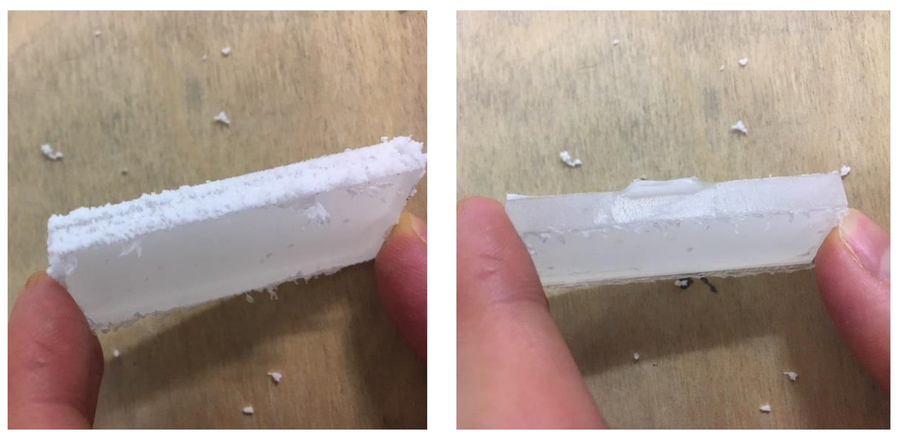



**Figure 4.** Final PCB design; includes transistor driving circuits and an interface between the CNC shield and Arduino Mega 2560.

## CNC Testing

A Computer Numerical Control (CNC) machine is used to mill the enclosure design out of Polyvinyl Chloride. While using the CNC machine is slower than cutting on a laser cutter, it gives a significantly better finish. Additionally, it can produce several more cut types, such as countersinking for bolt heads.

Initial test cuts on the CNC machine produce a rugged finish, Figure 5a. After additional research and discussion with a mechanical technician several changes are implemented: reduce spindle and feed rates, use more tabs to hold the piece still while cutting, and perform a spring run at the end to clean the part. Figure 5b shows the drastically improved results after these changes are made.



(a) (b)

**Figure 5**. (a) The first test cut made on the CNC machine. (b) A better finish on subsequent test cuts after specific changes are implemented.

## Enclosure Milling

The CNC milling is a lengthy process. Four different toolpath types are required to cut out all the parts. M6 holes are tapped and used to bolt the pieces together to increase rigidity. An amber UV filter will be applied to the transparent polycarbonate window to protect users from the laser, and to stop the photosensitive film reacting to light external to the enclosure. Figure 6 shows the constructed enclosure.

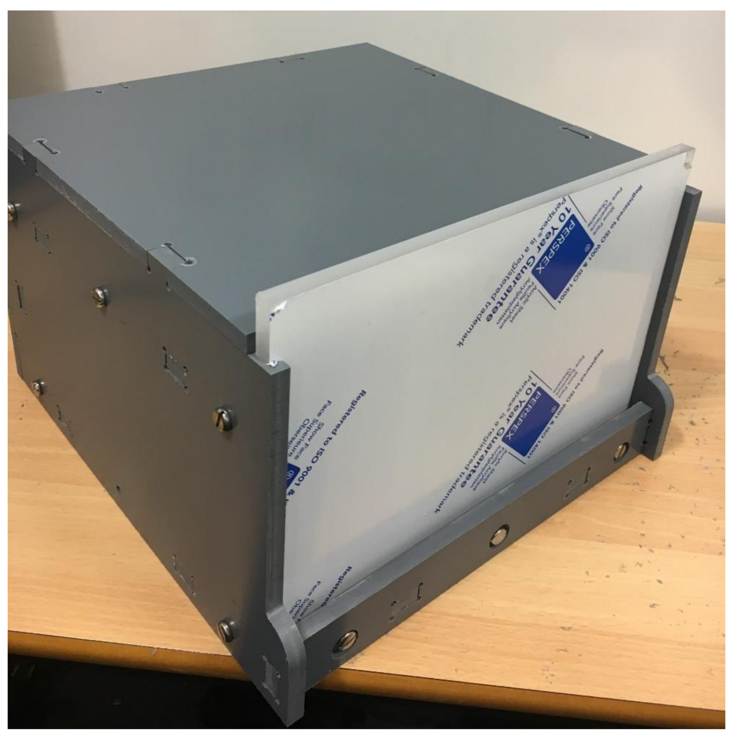


**Figure 6.** The enclosure is constructed from its constituent components. Protective covering is on the polycarbonate.

## PCB Manufacture

The board is manufactured by JLBPCB, who have a fair price as well as acceptable manufacturing time. Once the PCB arrives, male and female Single Inline Package (SIP) sockets are soldered onto the board. One-way sockets are soldered for the power connections; this stops users potentially plugging components onto the board incorrectly and damaging them.

**Figure 7.** The PCB with the CNC Shield and Arduino is mounted inside of the enclosure.

## References

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Department of Electronic & Electrical Engineering

UNIVERSITY OF BATH

[1] Department of Electronic & Electrical Engineering, University of Bath, Claverton Down, Bath, BA2 7AY, United Kingdom

* mtc47@bath.ac.uk