Electronic Hardware Design

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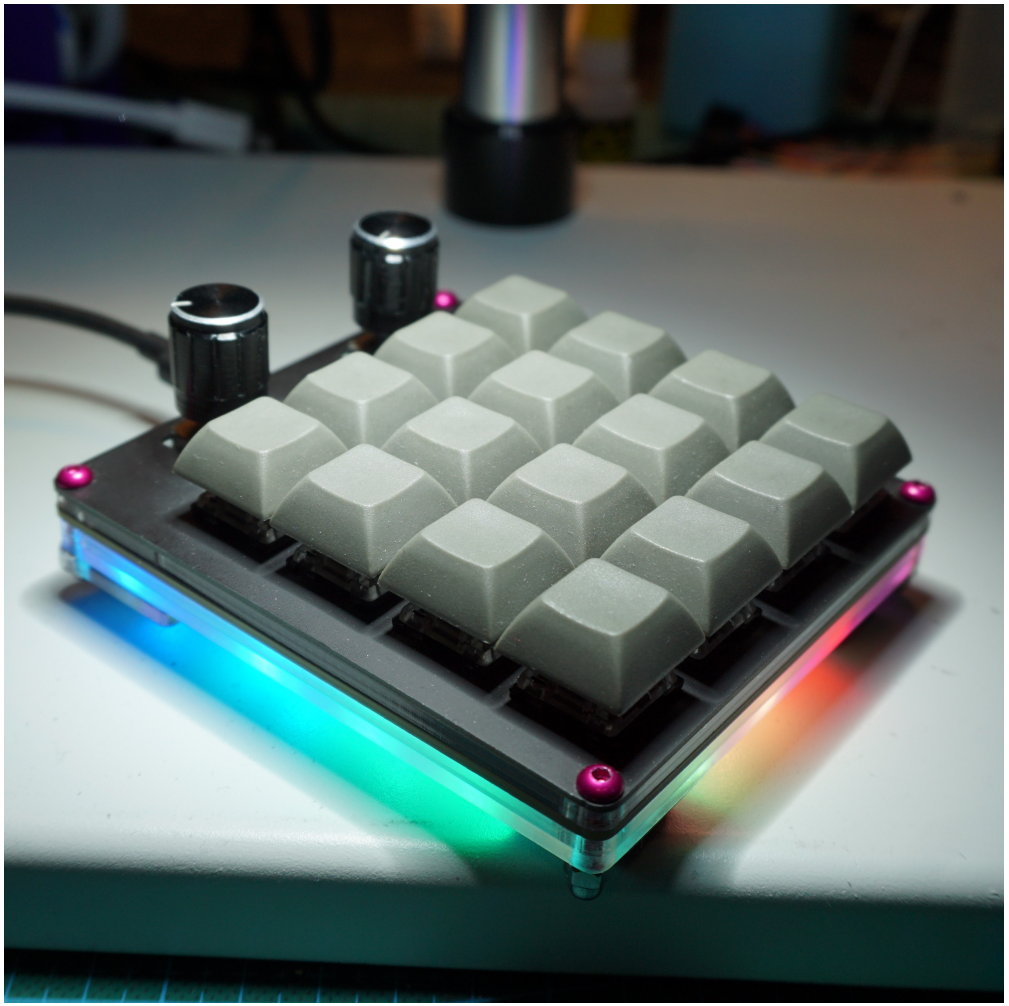
Overview

- What and why?
- Schematic Capture
- PCB Layout
- Ordering Boards
- Assembly
- Mechanical Design
- Firmware
- Profit?



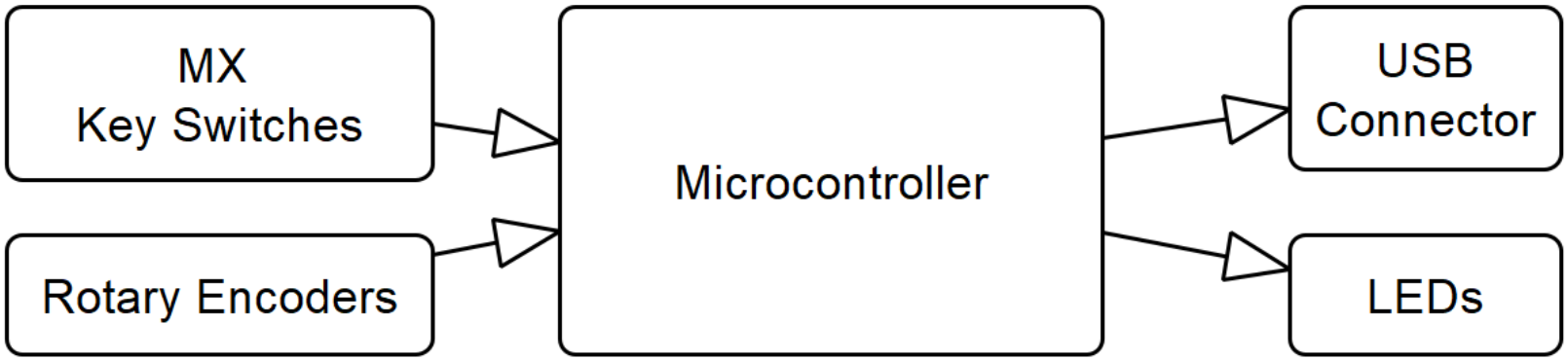
What and Why?

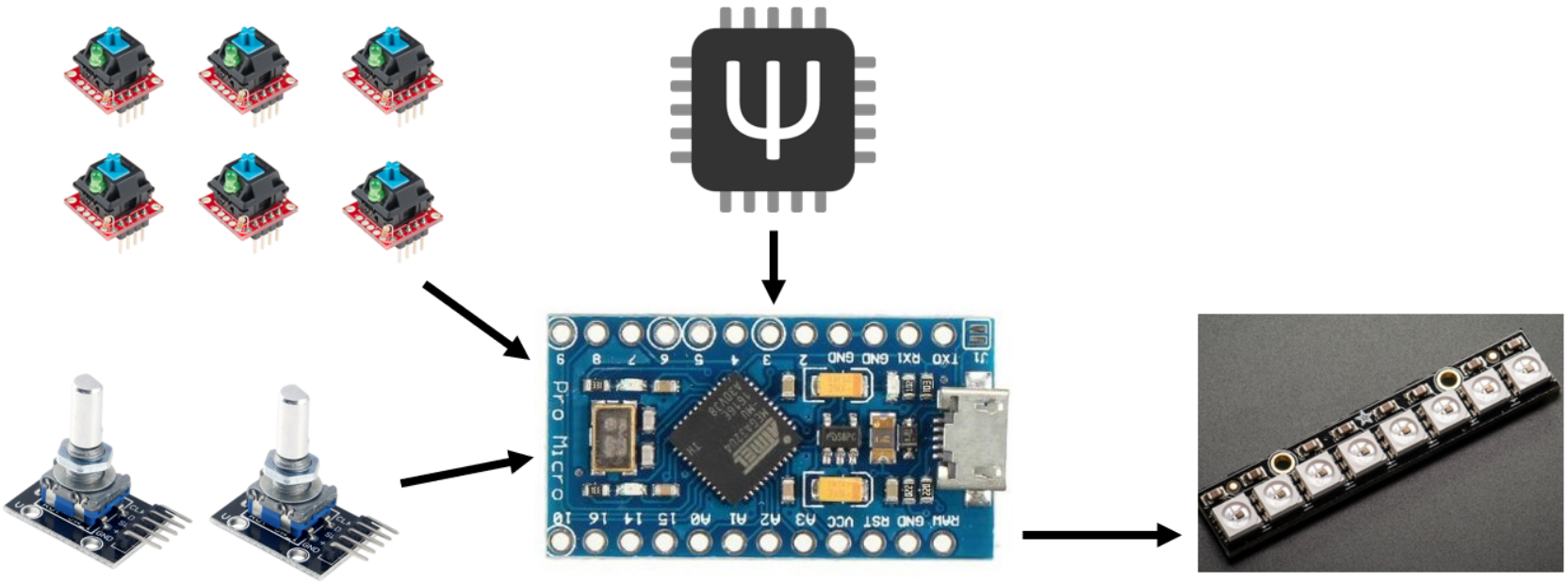
I wanted to build something to help with CAD

- Reprogrammable - able to send HID codes natively
- Rotary Encoders - at least two
- RGB LEDs
- Cheap

Nothing available, so time to build my own!

Block Diagram





Reference Designs

We have picked our parts, but how do we figure out the schematic?

- Adafruit / Sparkfun Breakout Boards
- Evaluation Boards
- Application Notes
- Datasheet

With a reference design in hand, time to draw up the schematic

EDA tool of choice: KiCad

A Cross Platform and Open Source Electronic Design Automation Suite

- KiCad - project manager
- Eeschema – schematic capture
- Pcbnew - layout program
- GerbView - gerber viewer
- Bitmap2Component - import images to PCB

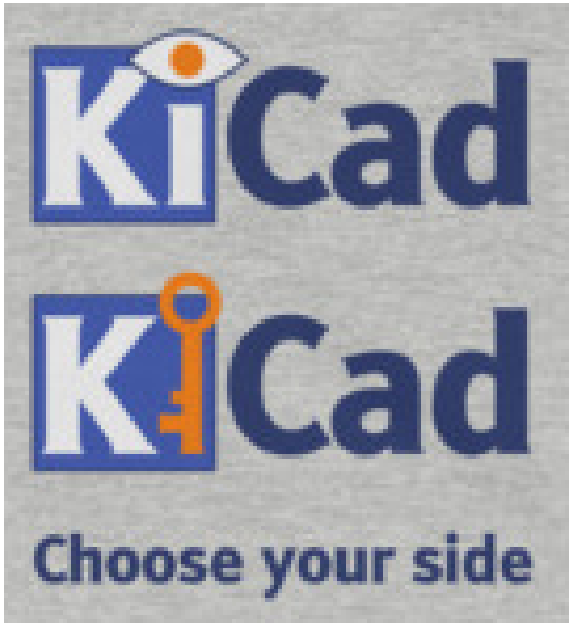
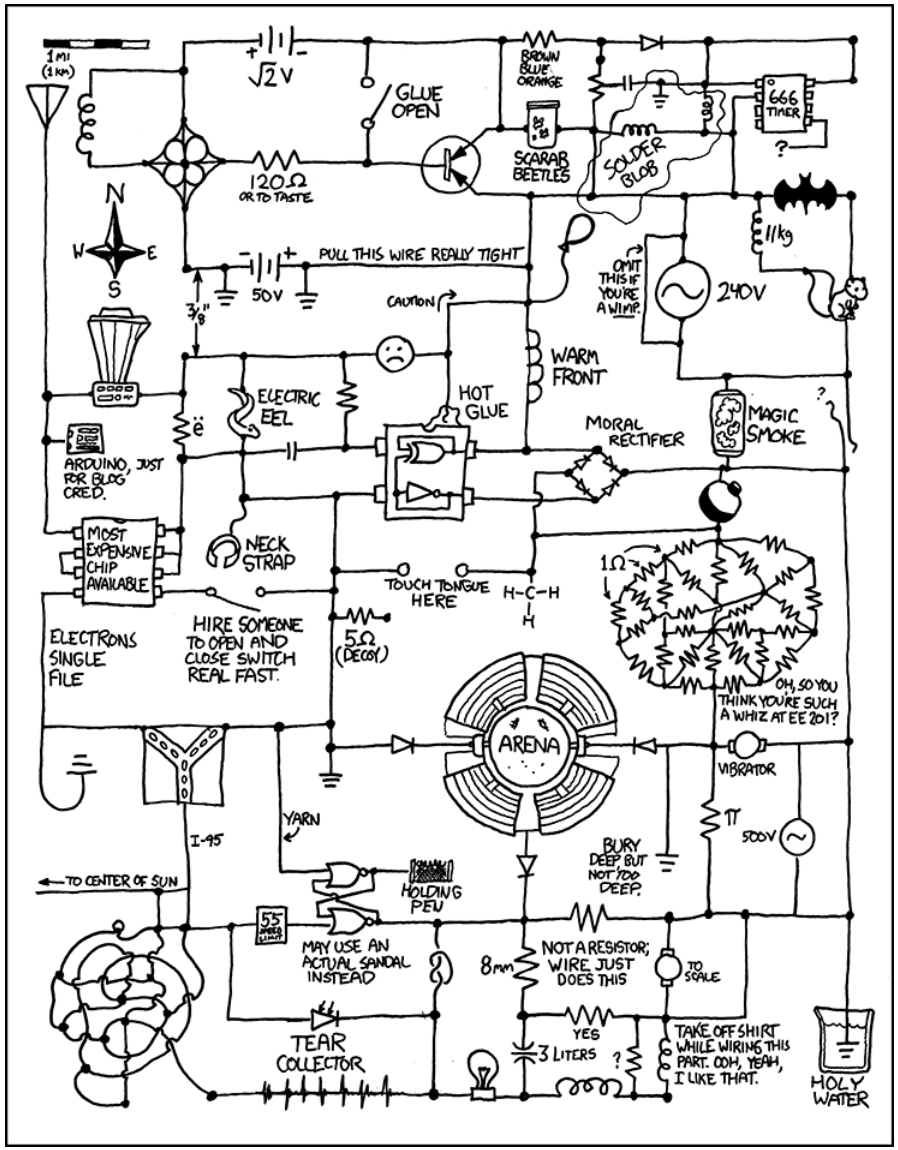


Image:
@Chris_Gammell

Schematic Capture

- Abstract representation of circuit
- Abstract representation of components
- Drawn for ease of understanding
- Communicates purpose
- Documents design!



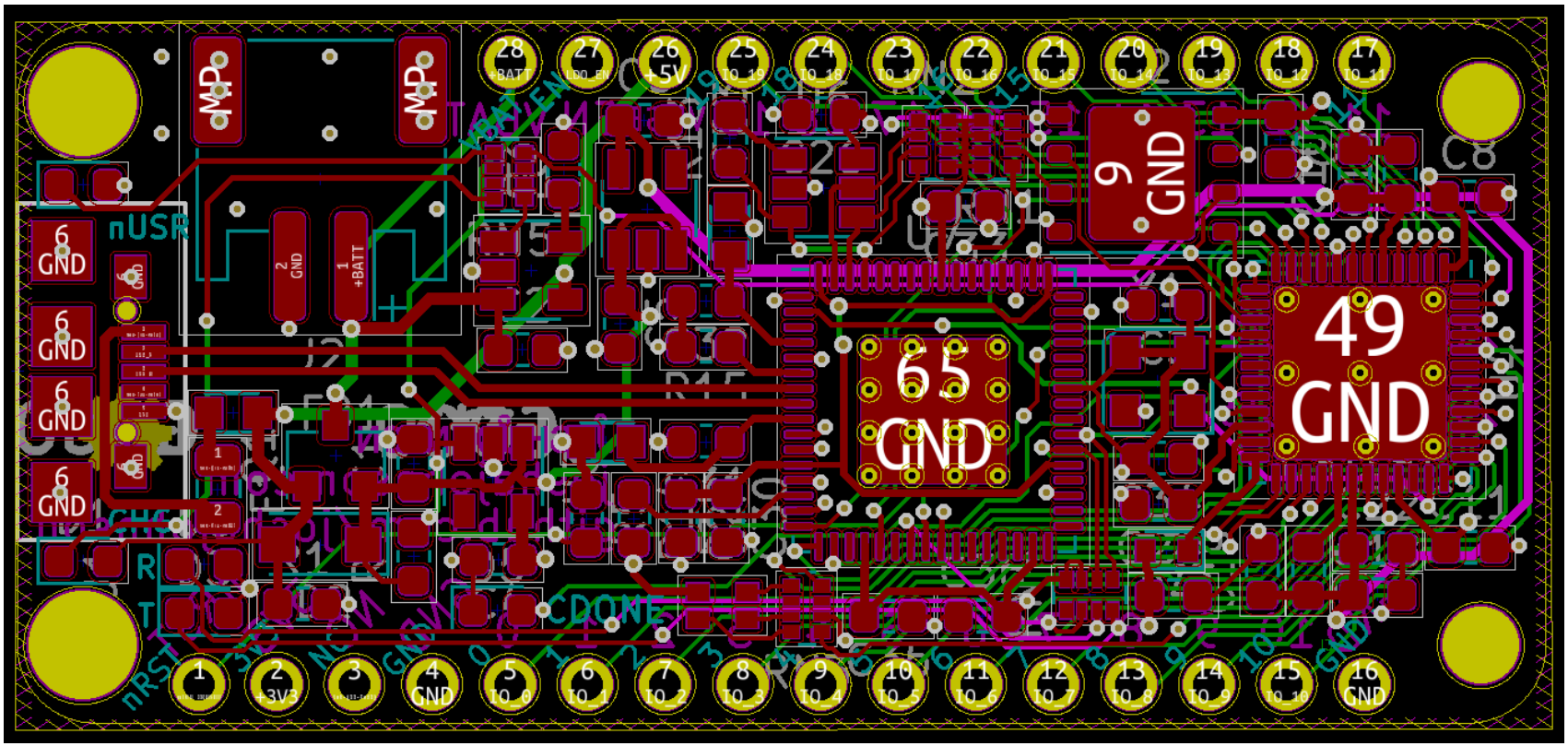
Schematic Capture

Key Steps:

- Symbol creation
- Symbol placement
- Connect everything with wires
- Electrical rule check (ERC)
- Footprint association
- Bill of Materials (BOM) generation

PCB Layout

- Physical representation of circuit
- Physical representation of components
- Layout conforms to electrical and mechanical requirements



Determine Manufacturer

- Manufacturers have design rules for the smallest feature sizes they can manufacture
- PCB thickness, colour, material, trace/space, surface finish, and physical dimensions all alter cost
- Figure out who will manufacture the boards before layout, or it may come back to bite you

PCB Stackup

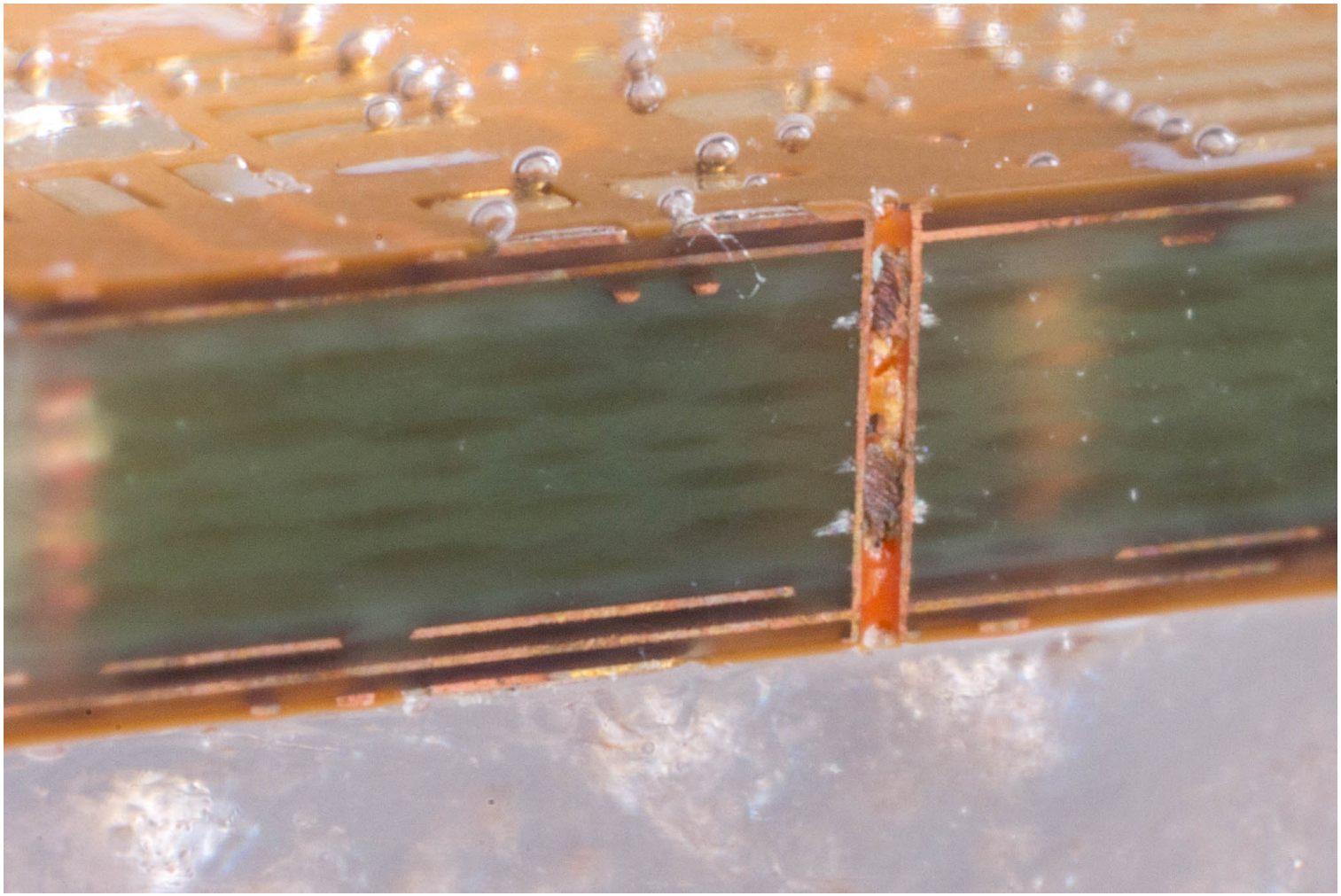
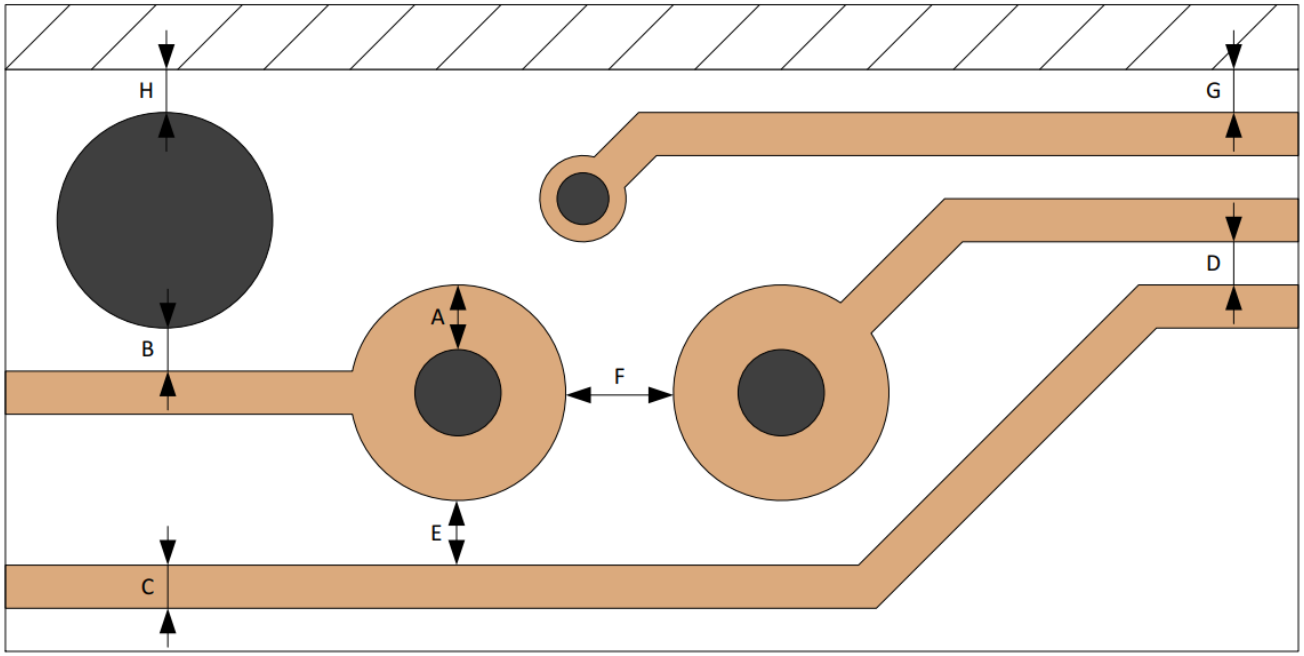


Image: @GregDavill

Key Design Rules



- Min track width / spacing (C / D)
- Min drill size (Not Shown)
- Min annular ring (A)

More: `http://www.lintek.com.au/wordpress/wp-content/uploads/Design-Capabilities-v2.7.pdf`

PCB Layout

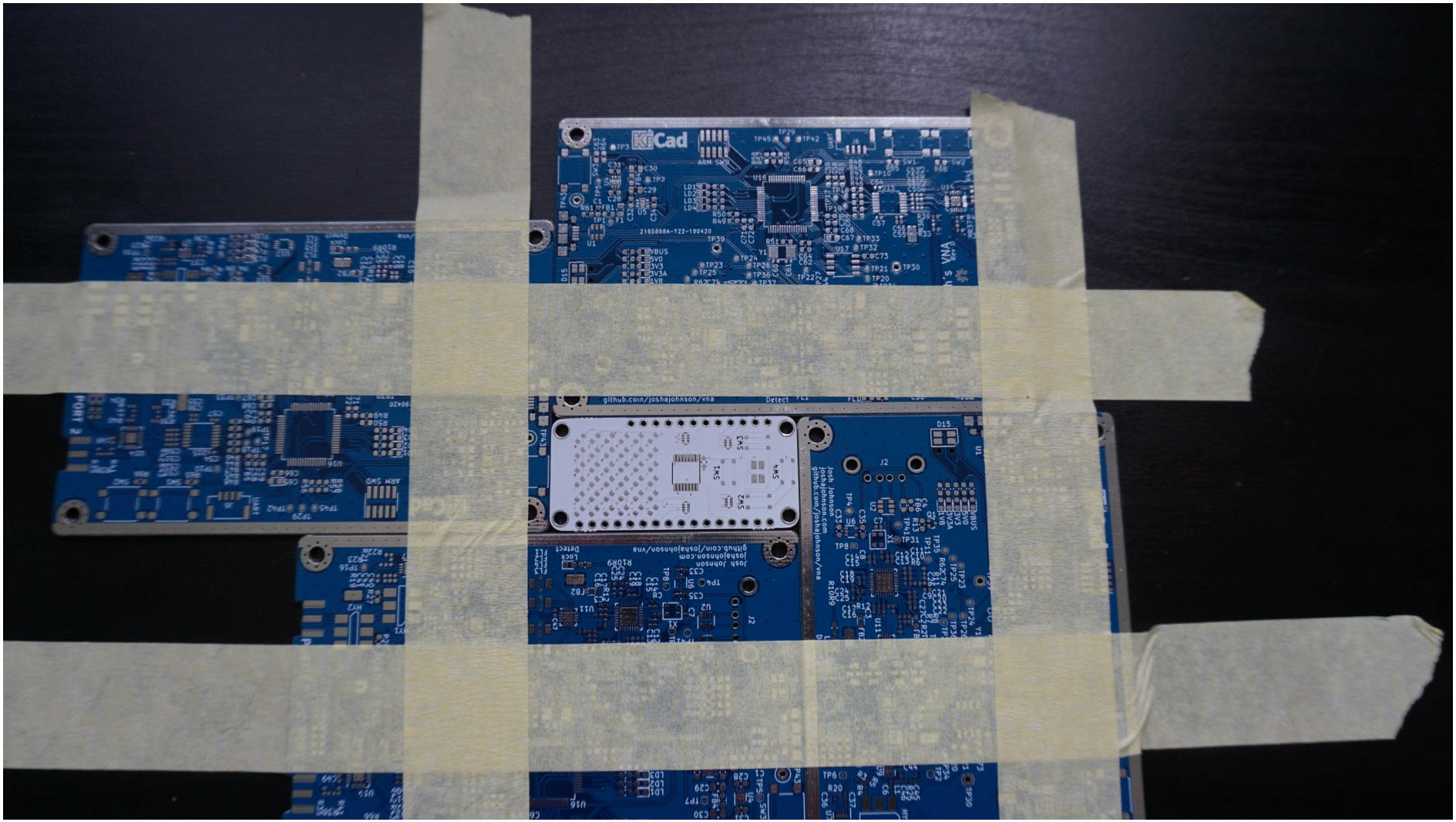
Key Steps:

- Configure design rules and board setup based on manufacturer guidelines
- Place connectors, mounting holes, other mechanical components
- Place electronic components
- Route critical nets
- Route power
- Route everything else
- Add decorative features
- Run design rule check (DRC)
- Export Gerbers
- Generate iBOM Pick and Place

Ordering Boards

- Check Gerbers in GerbView
- Zip up Gerbers
- Upload to manufacturer
- Choose PCB options
- Place order
- Don't forget to order parts!

Assembly



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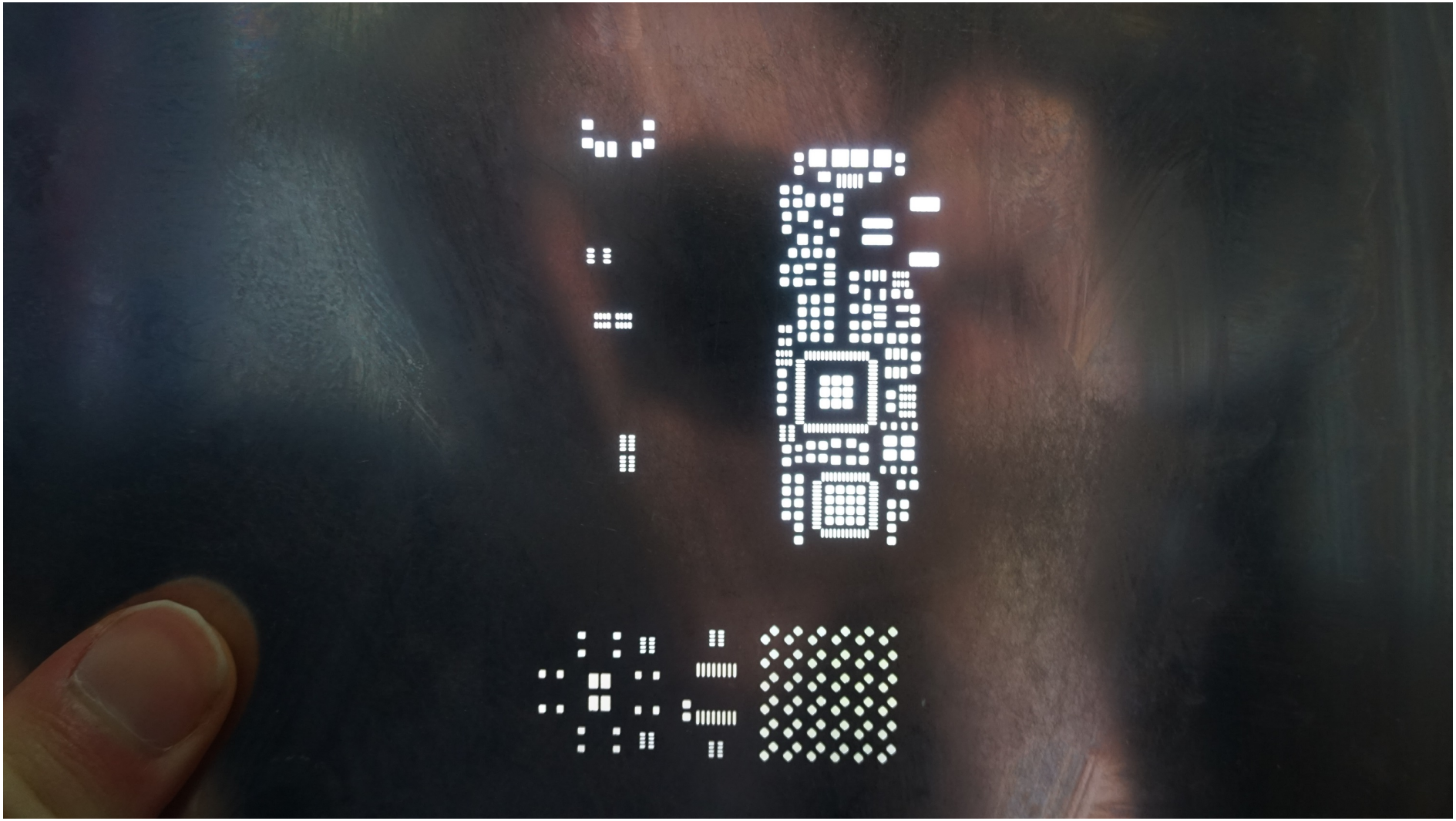

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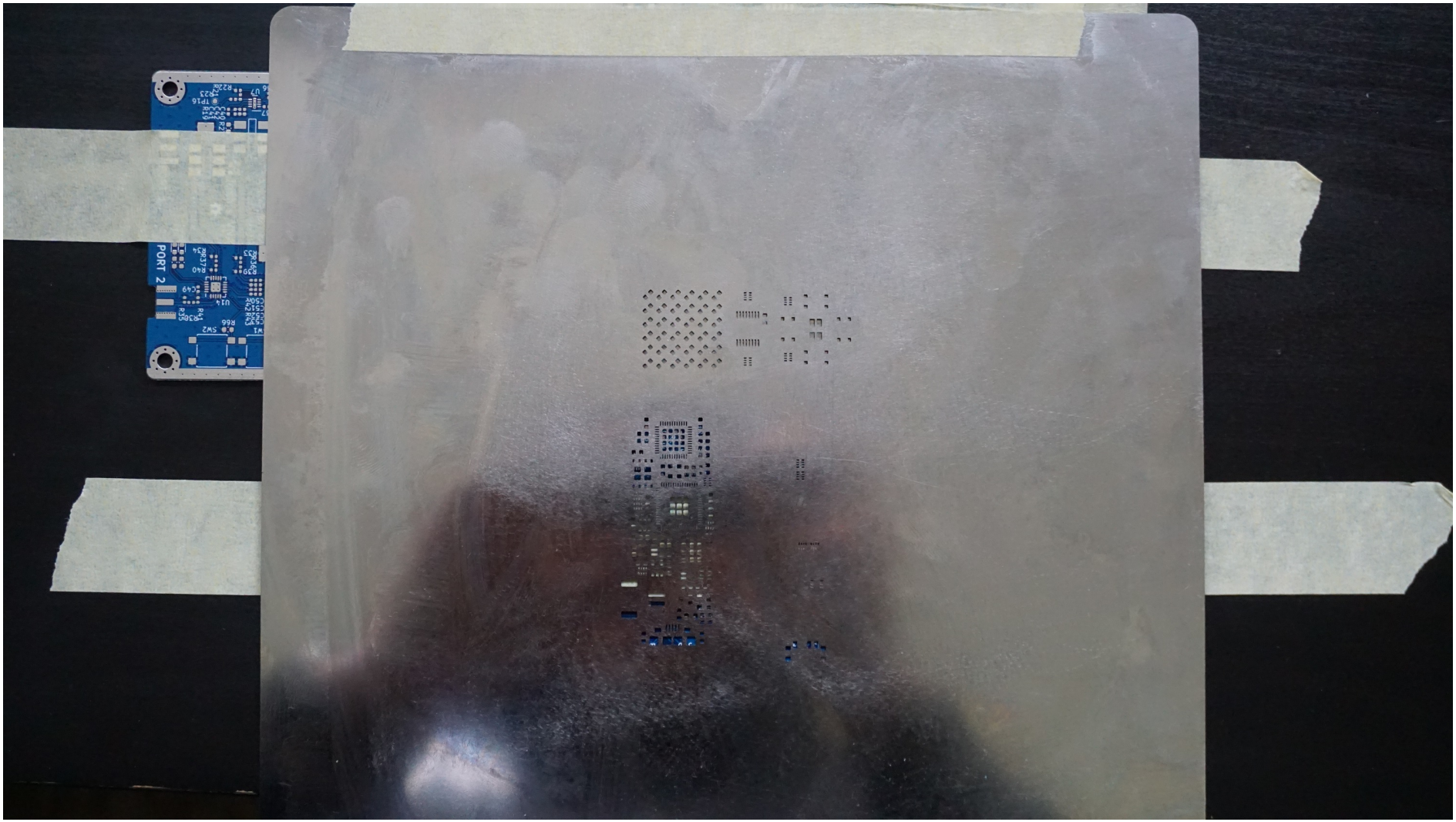

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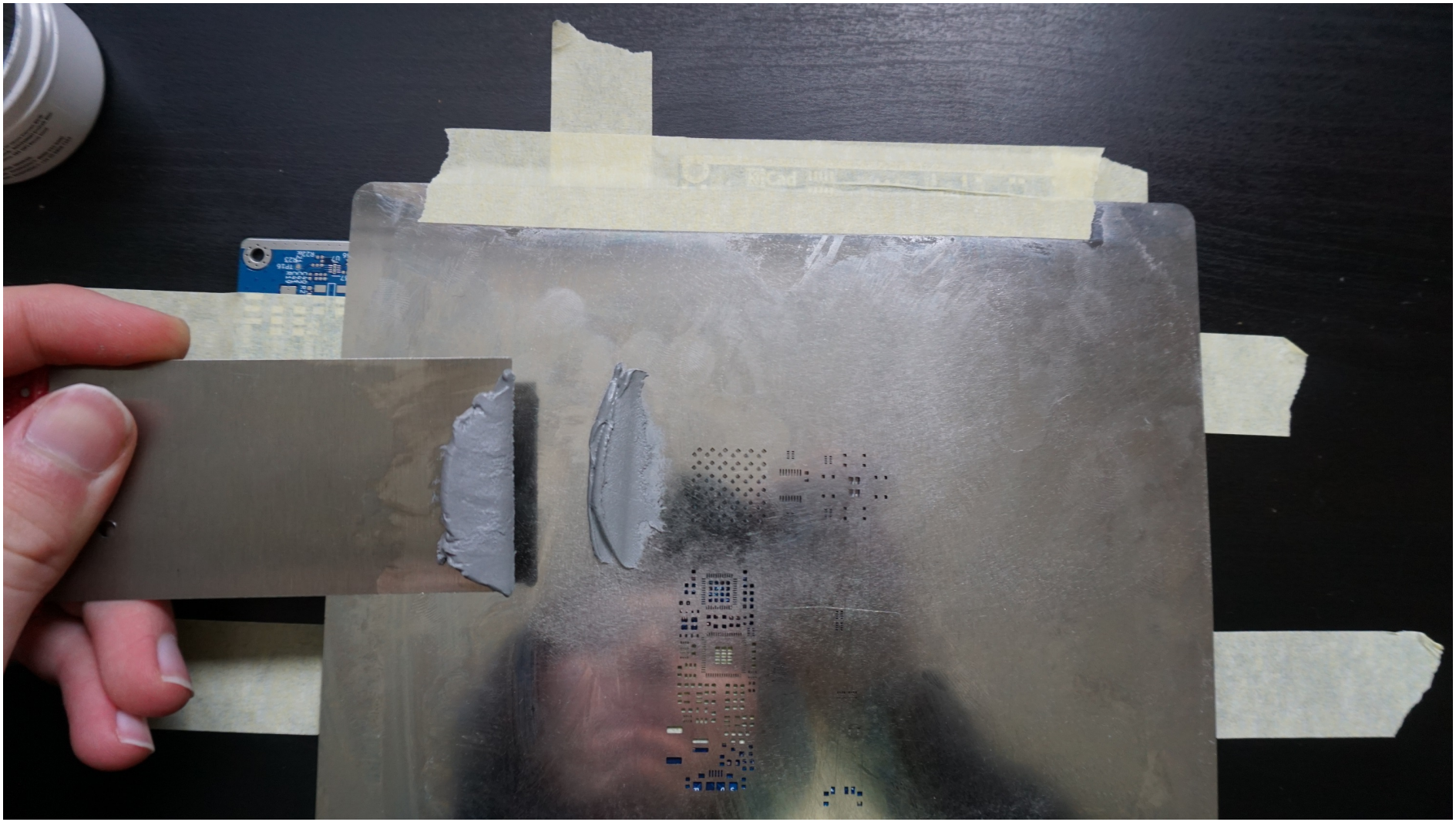

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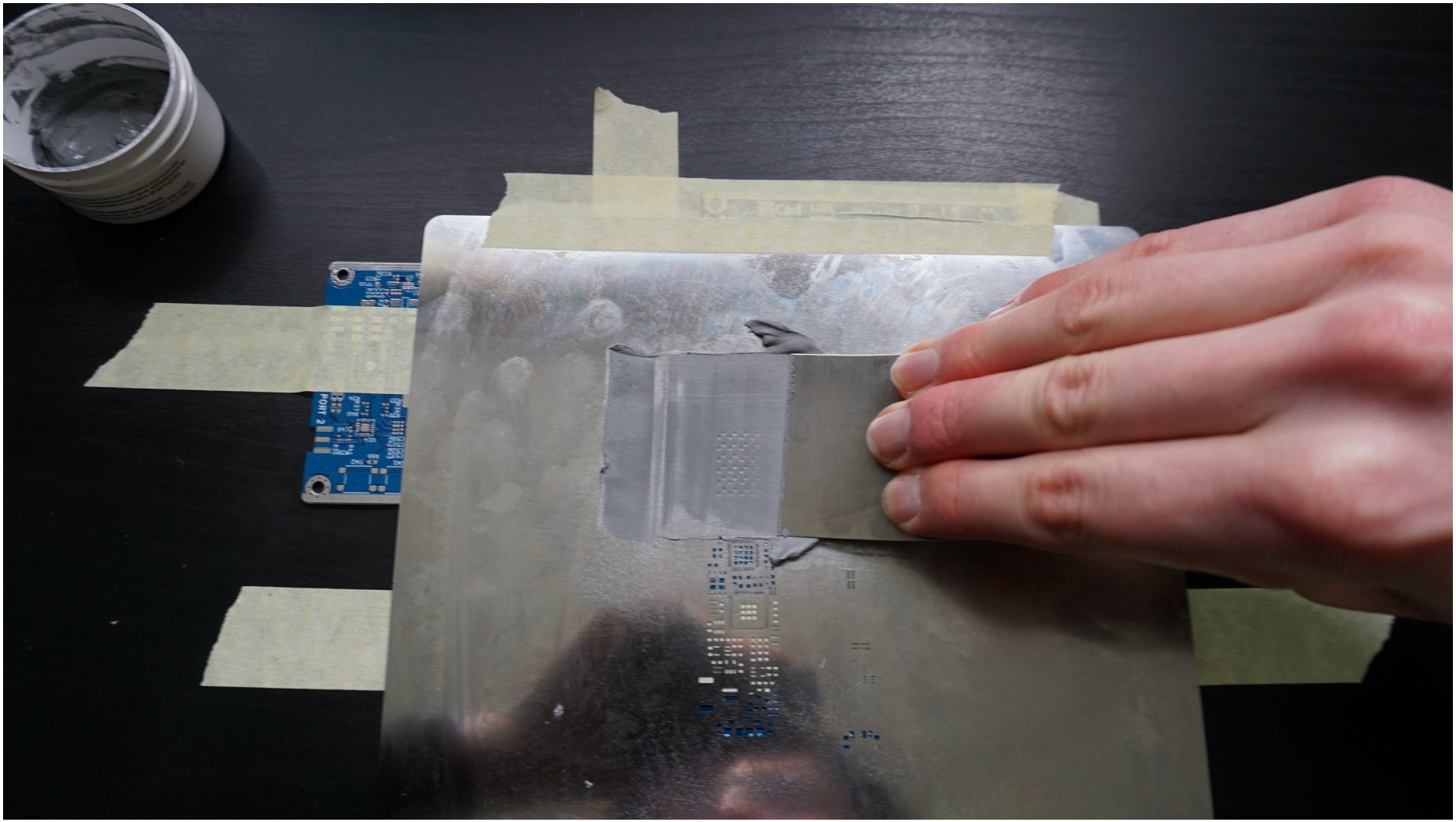

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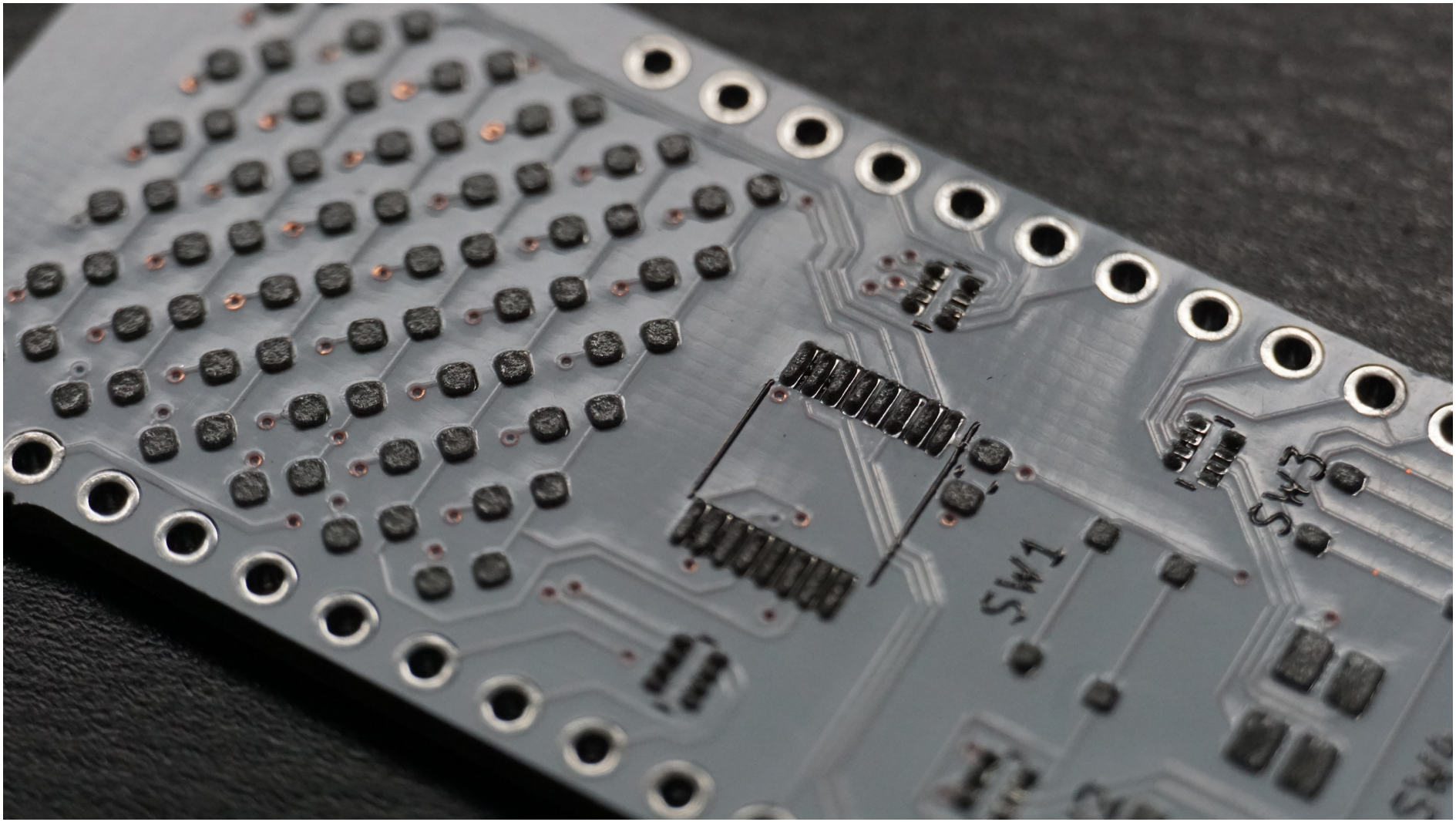

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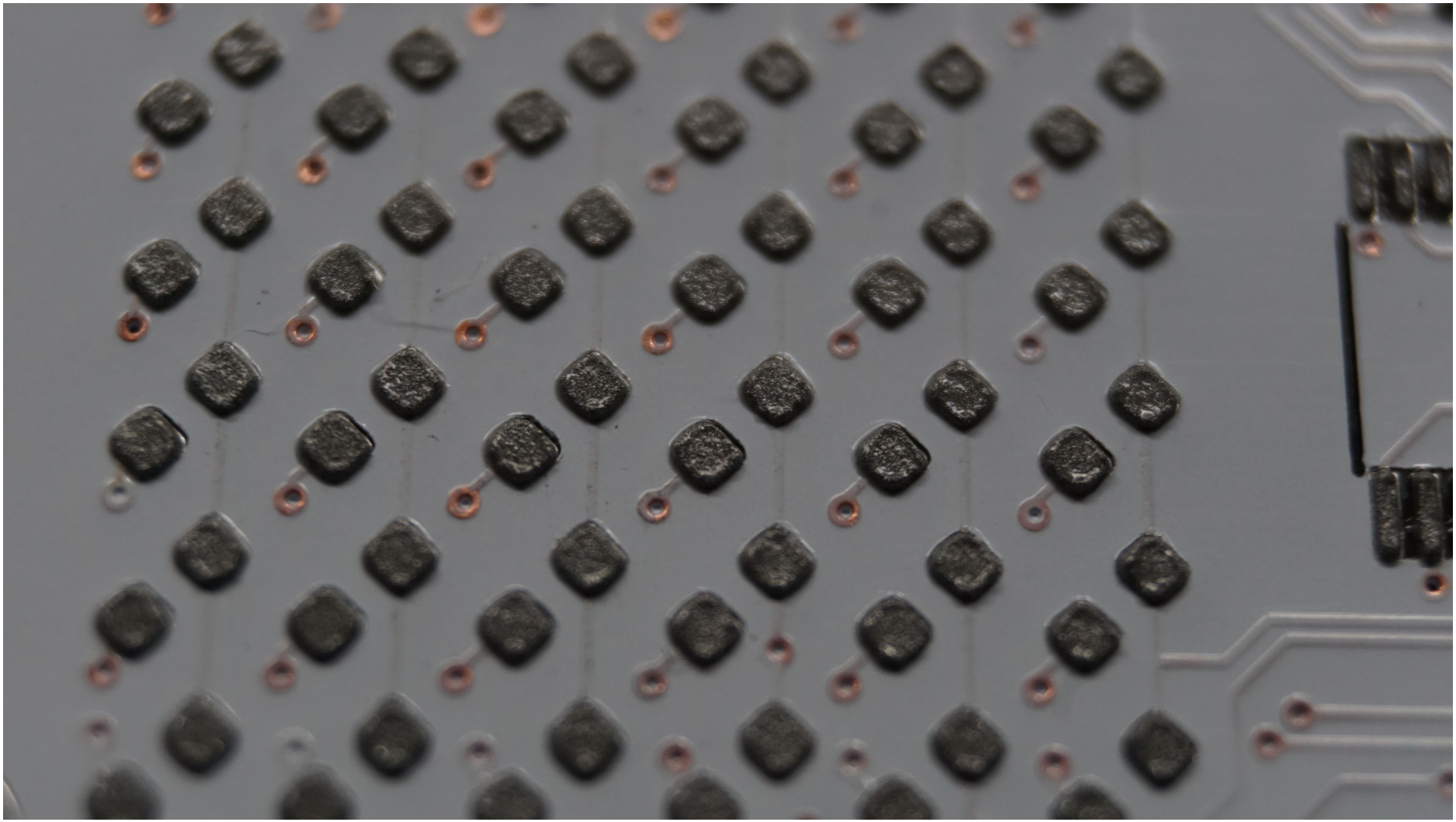

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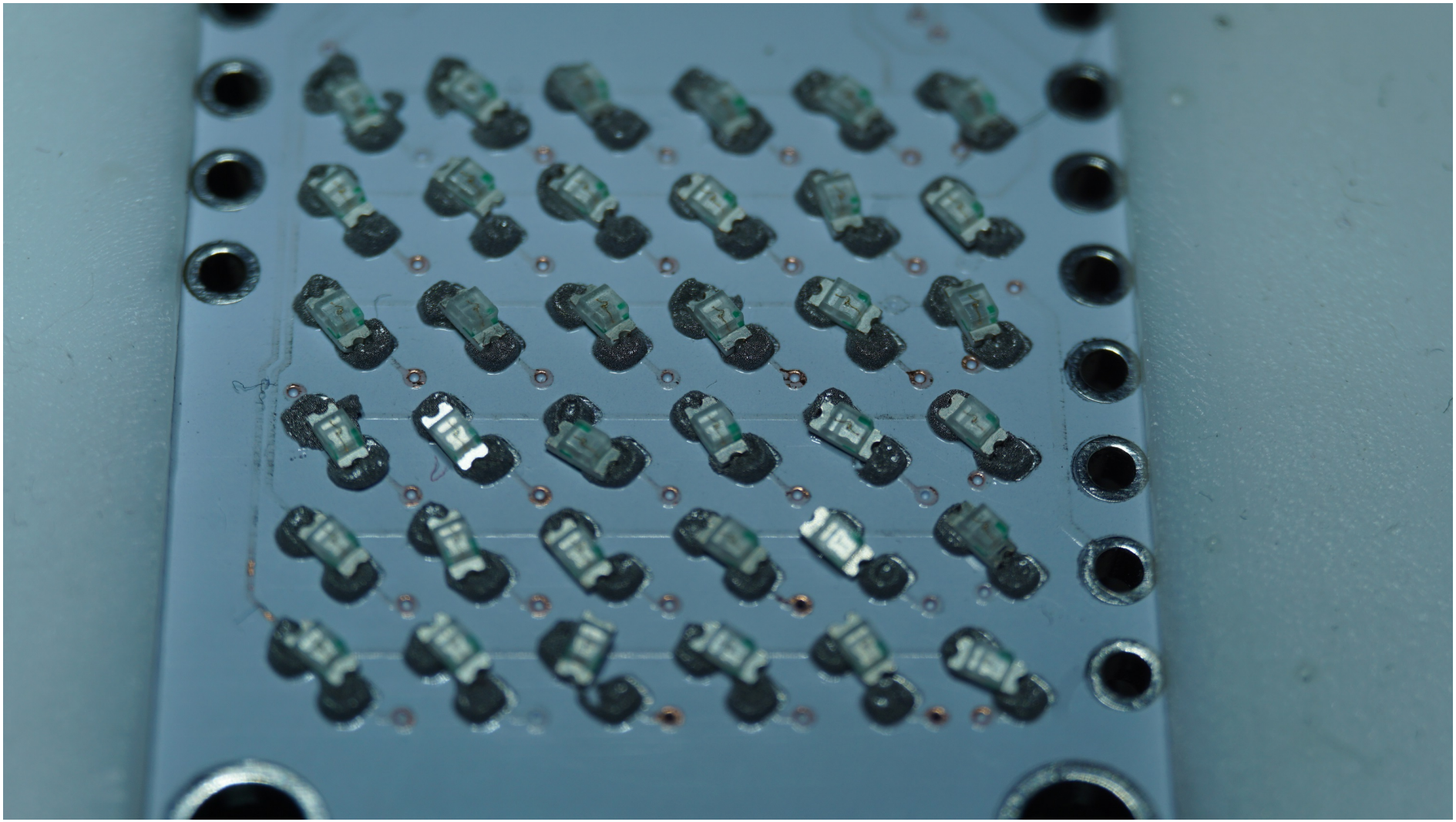

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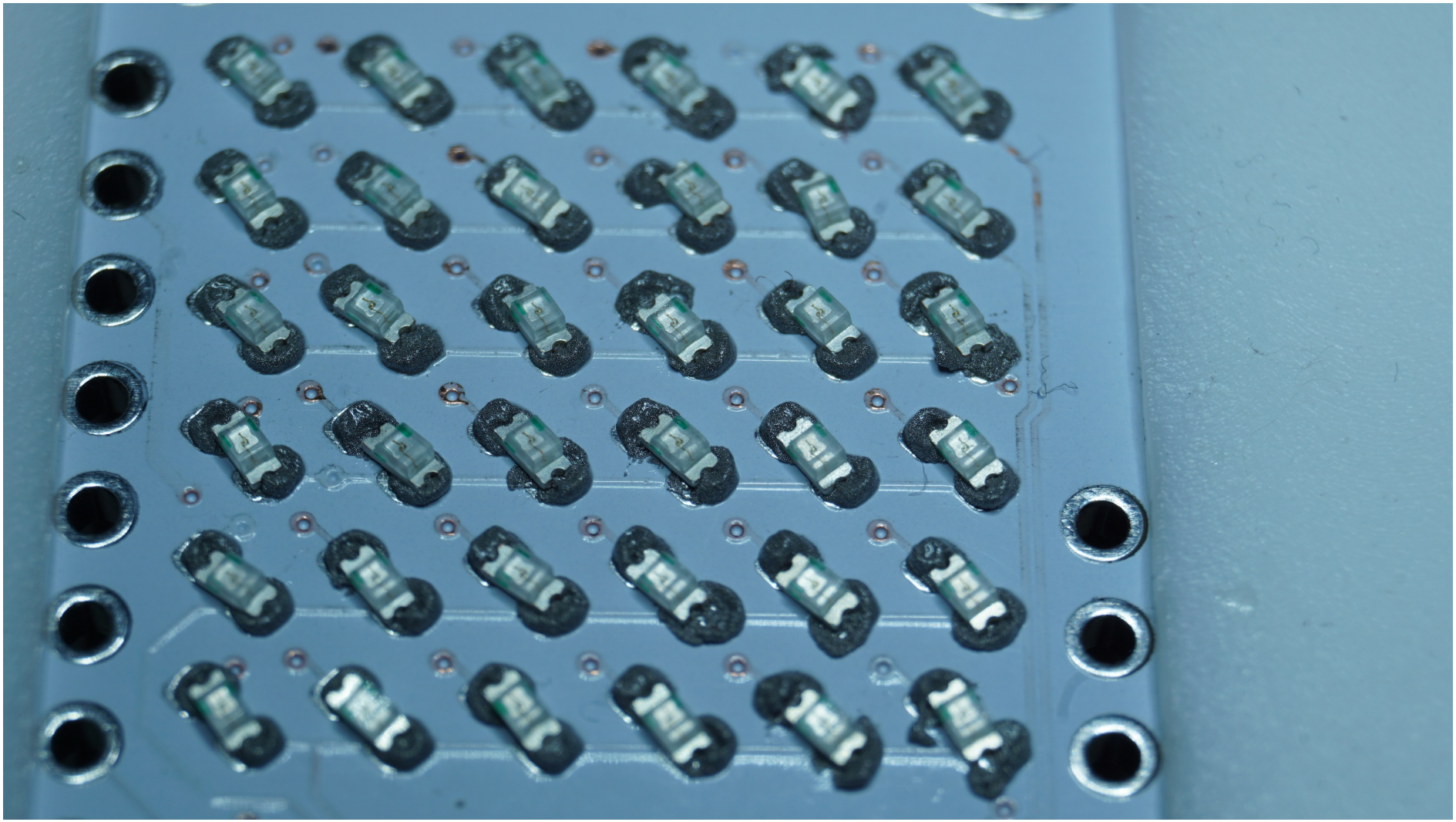

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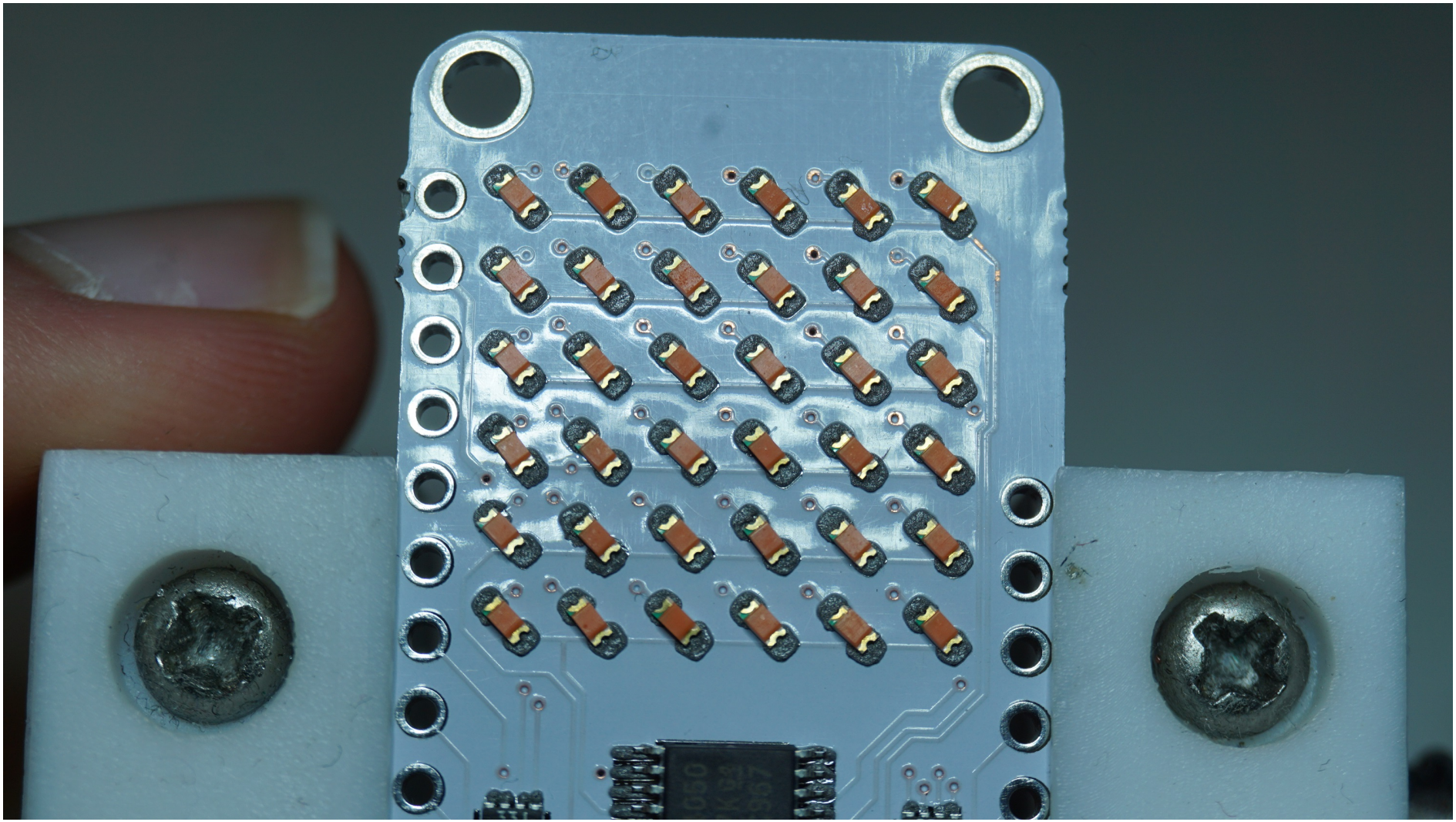

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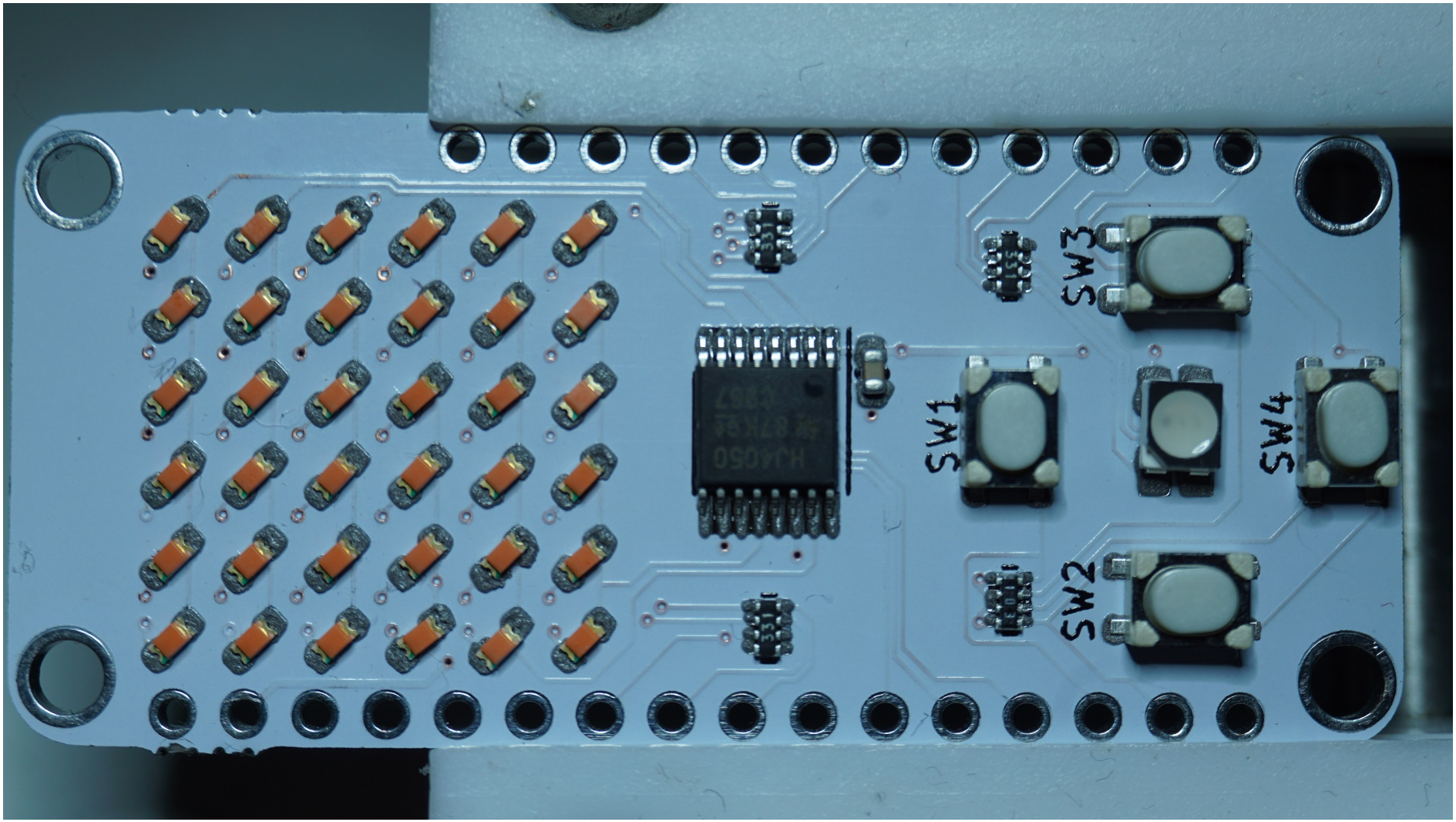

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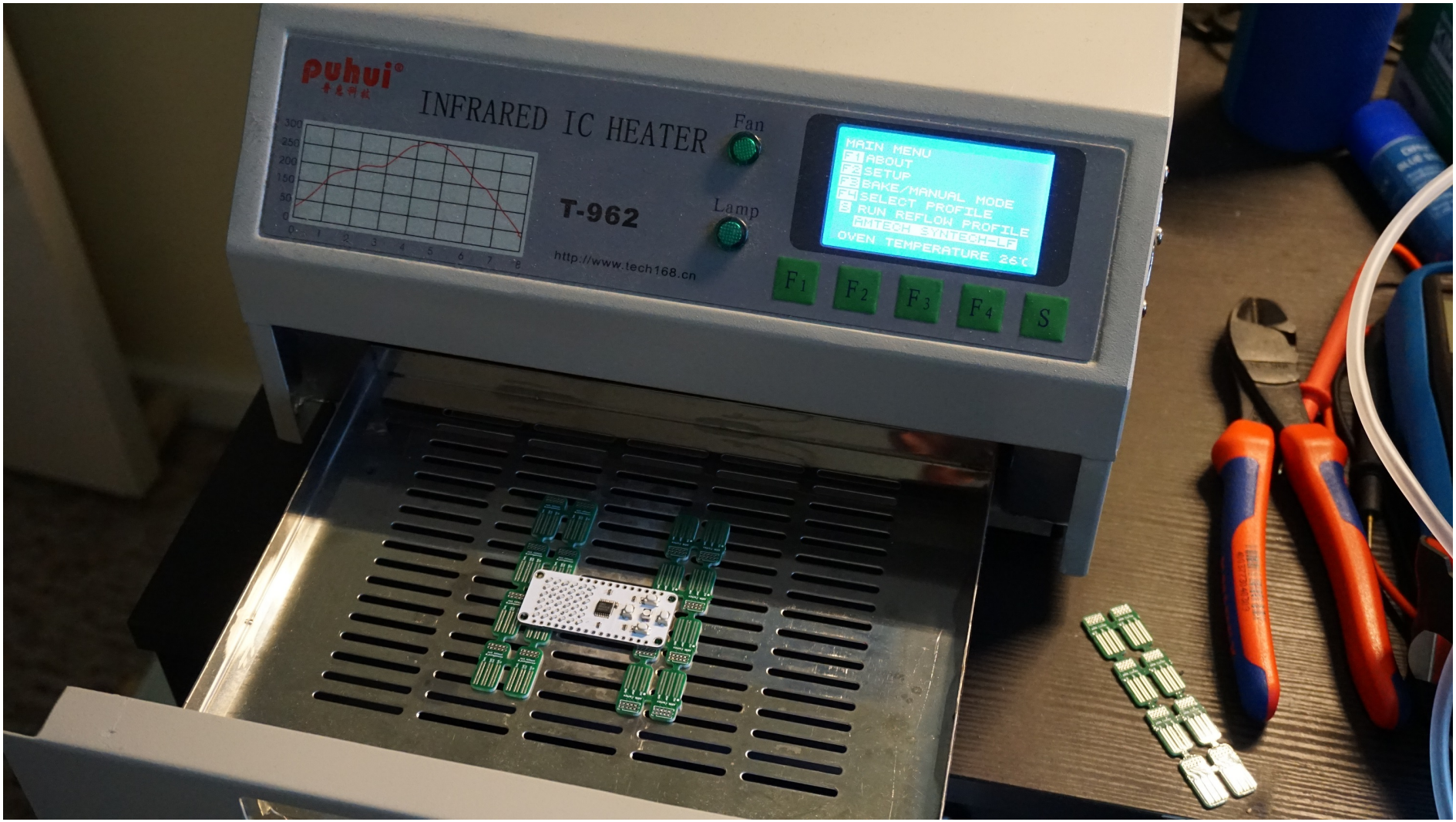
puhui
INFRARED IC HEATER
Fan
Lamp
T-962
http://www.tech168.cn
MAIN MENU
F1 ABOUT
F2 SETUP
F3 BAKE/MANUAL MODE
F4 SELECT PROFILE
S RUN REFLOW PROFILE
OVEN TEMPERATURE 26℃
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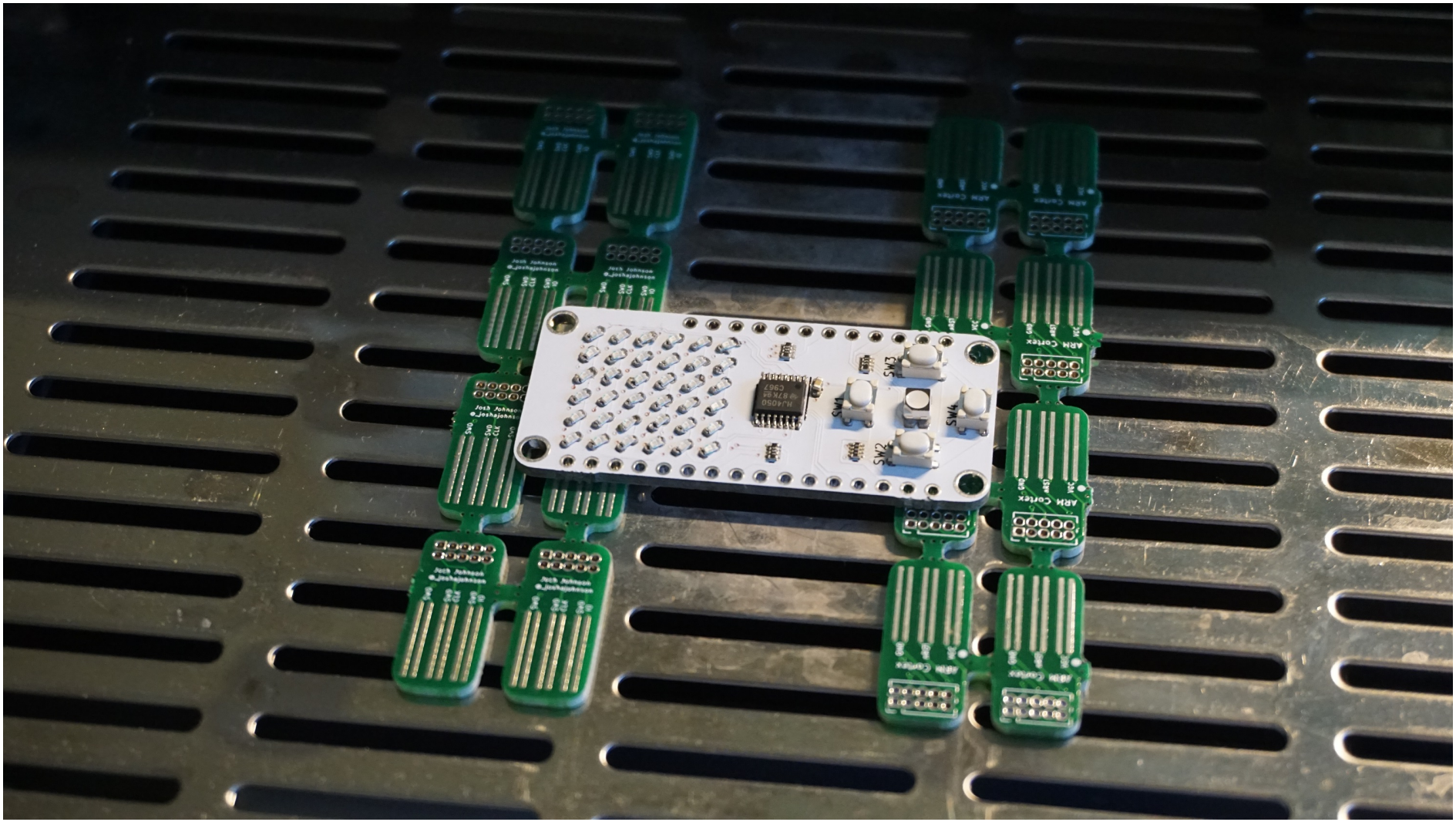
Assembly



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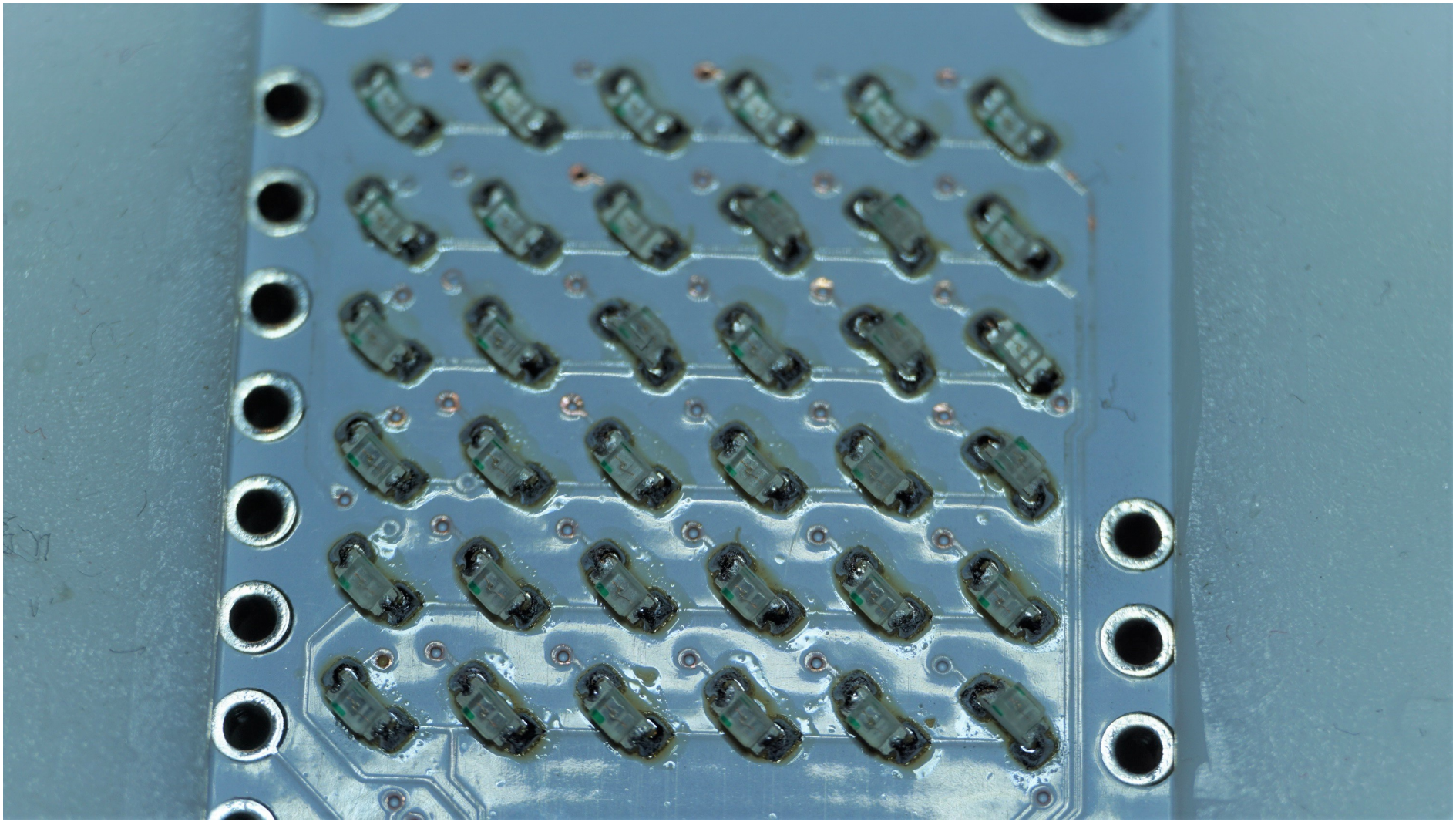

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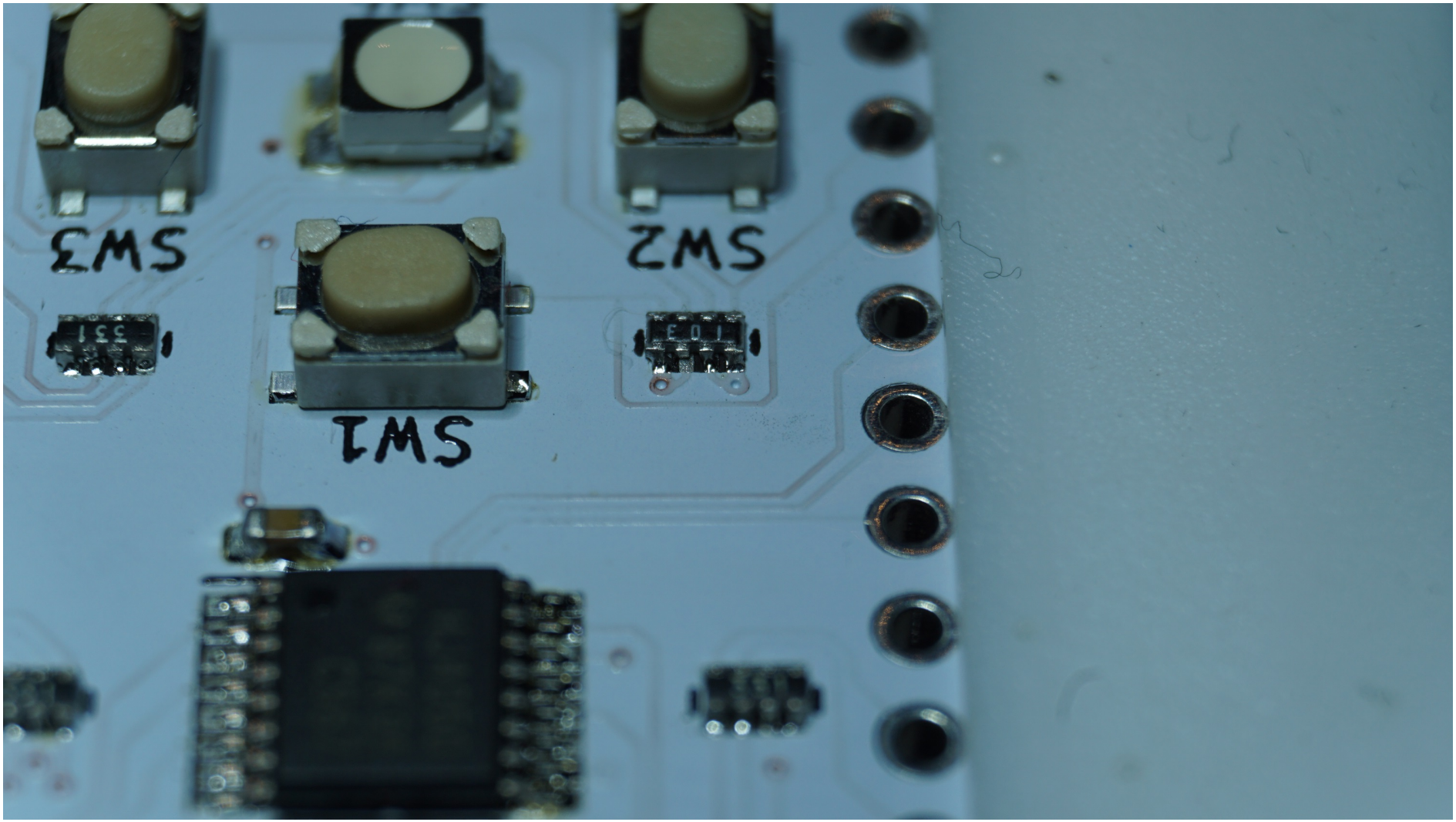

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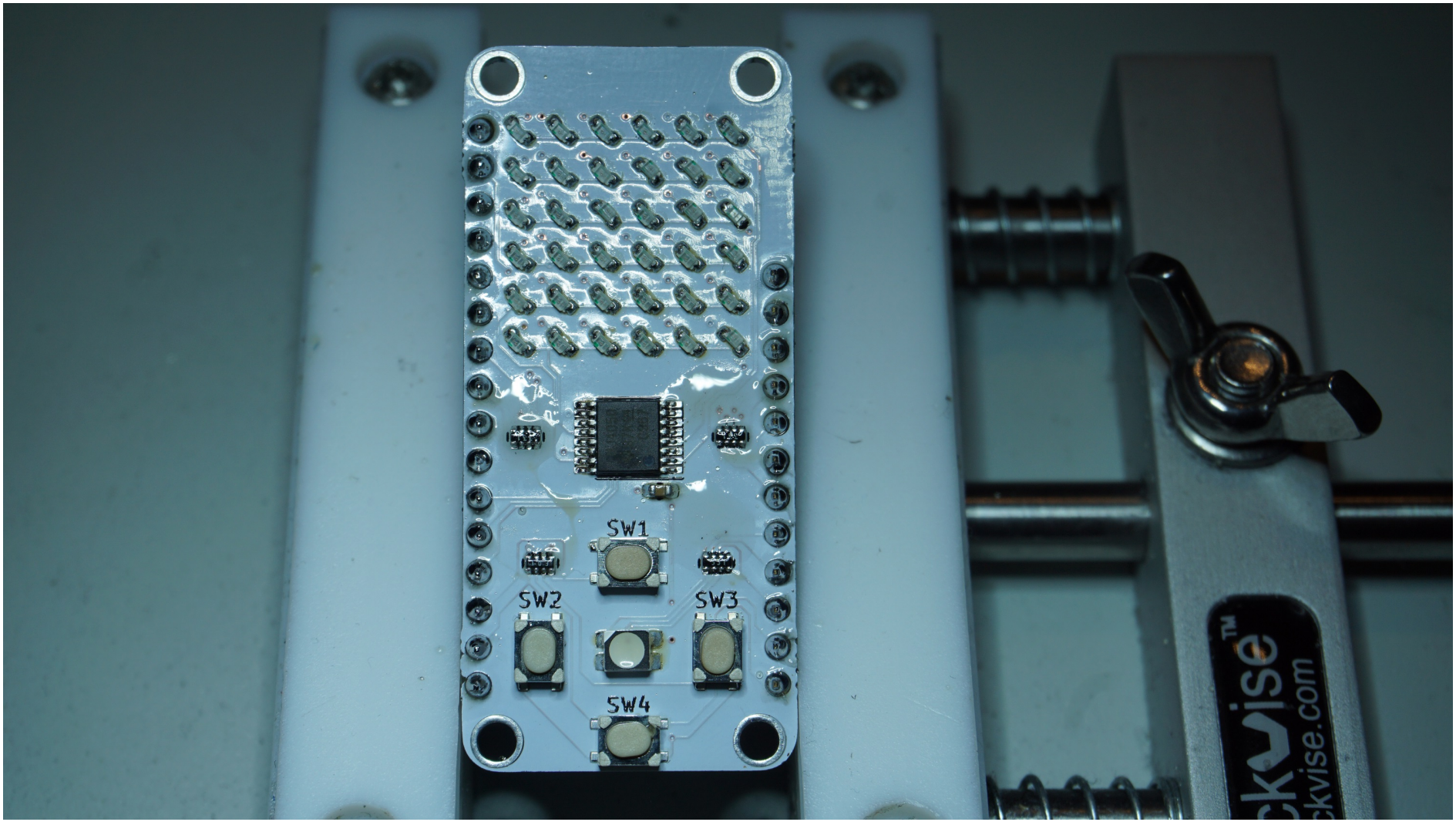

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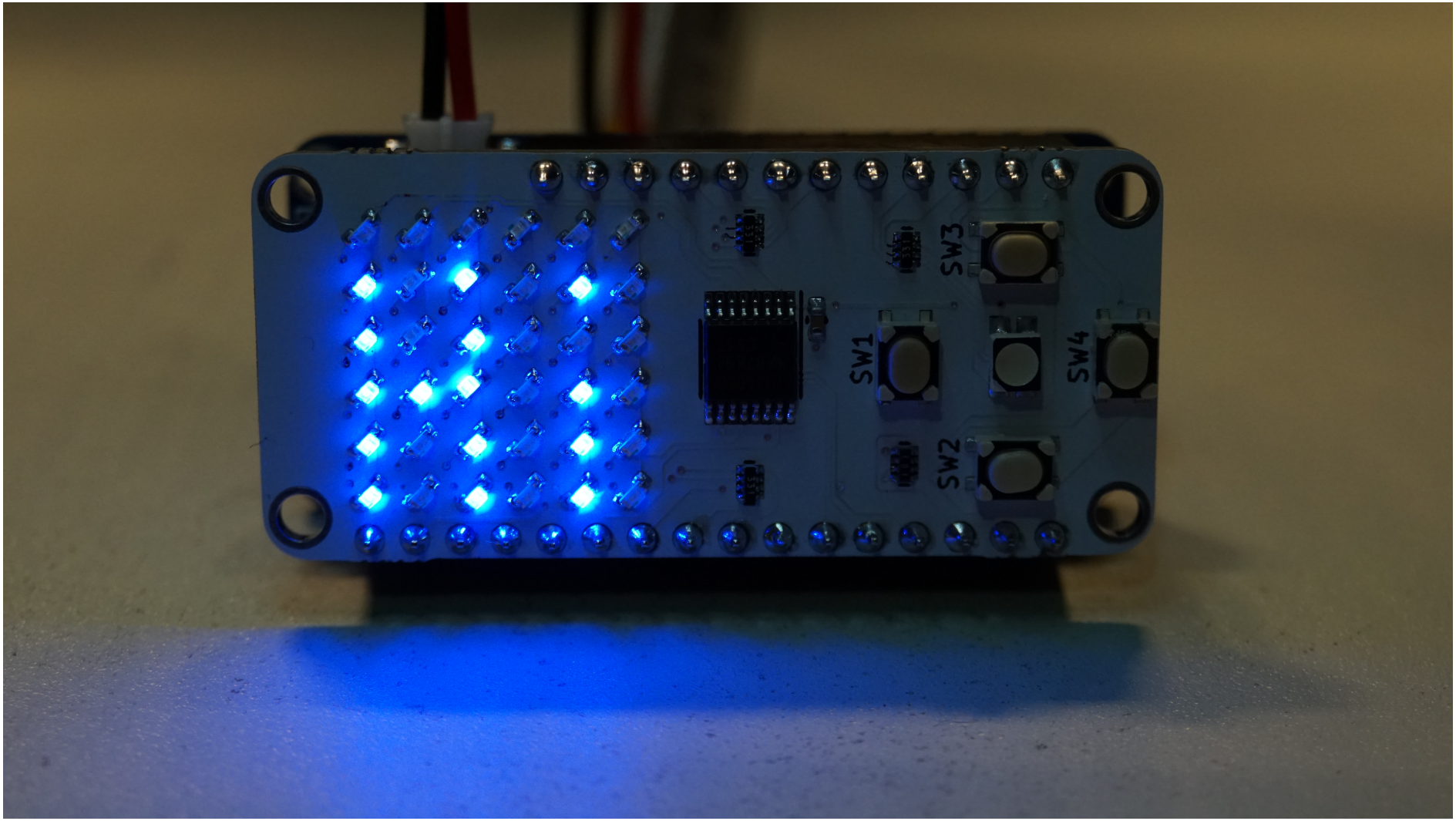


Mechanical Design

Circuit boards are nice to look at, but sometimes they need an enclosure

- Laser cutting
- 3D printing
- COTS enclosures
- PCB as a custom faceplate

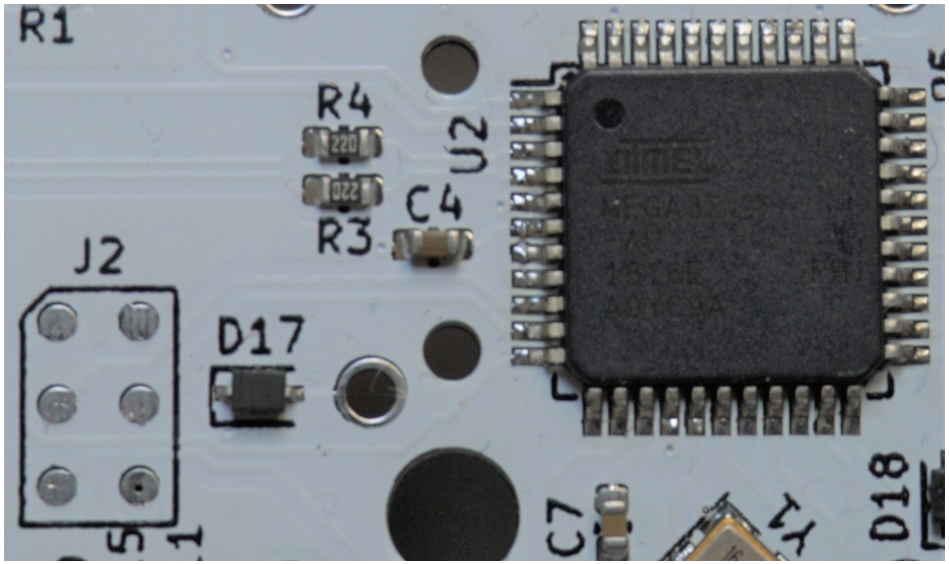
Easiest way to design / ensure fit - export PCB from KiCad to MCAD

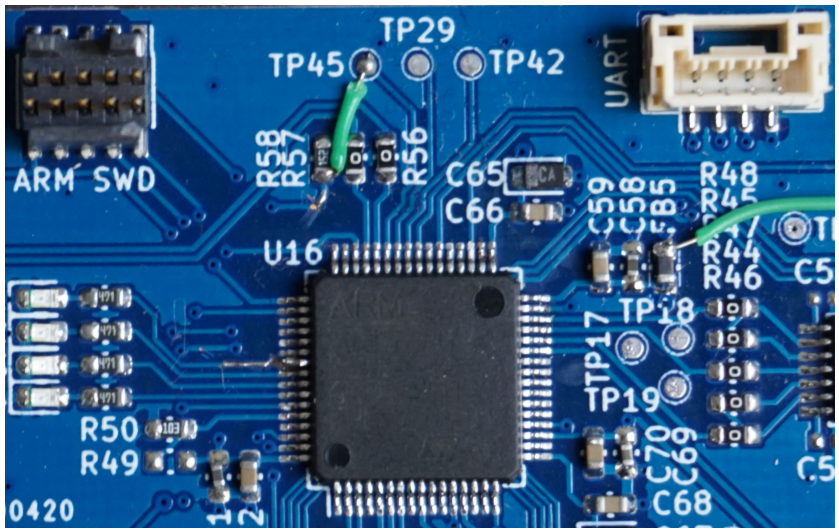
You can also import .dxf from MCAD into KiCad, and use that for mechanical design

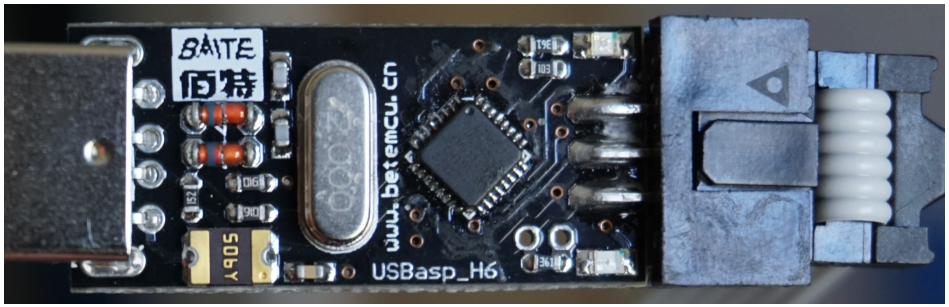
Firmware

We have assembled the board, but we now need to program it. How?

- Unlike an Arduino, new ICs typically lack a bootloader
- We need a programming header on the board to flash firmware
- Header may also be used for debug







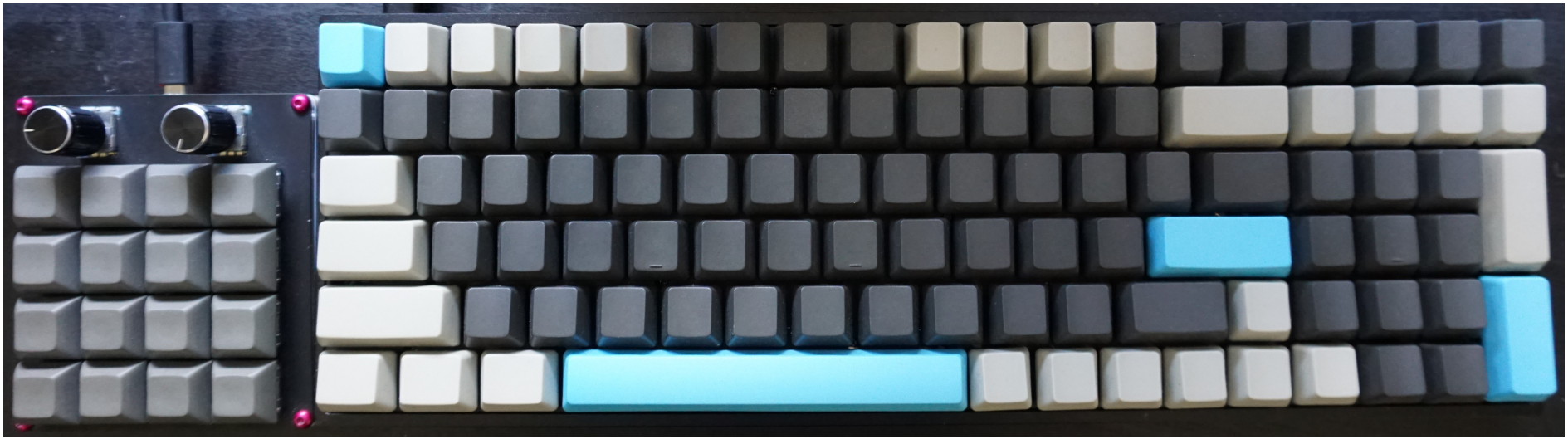
Keyboard Firmware

Current Configuration

- Arduino Caterina Bootloader
- Running QMK firmware
- Sends unused HID codes over USB
- AutoHotKey converts these into desired key presses, depending on open window
- Allows for macros to be set for KiCad / Chrome / Fusion 360 etc

HID codes could also be hard coded to desired combinations on device

Final Product



- I now have a custom keyboard which is not only great for CAD, but is used for multiple applications on my computer
- During the build, learnt of / how powerful QMK is, so bought a full size keyboard which runs QMK firmware
- Now have two completely reprogrammable keyboards, which not only increase productivity, but have been configured to help mitigate RSI issues

Profit?

Shitty Add-Ons

Images: @mrtwinkletwink, @BSidesCbr

Shitty Add-On

Design your own!

Check out the `SAO/SAO101.pro` KiCad project
Schematic capture is complete, components are ready to be laid out, just need to connect the dots!

Questions?

Slides and Files: `github.com/joshajohnson/CBRhardware`

README contains links if you want to learn more

Happy to help out anyone designing a board, feel free to get in touch.

I have lots of circuit boards on me, please say hello!

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BSidesCbr Slack: josh