A Brief Review of My Research Projects in Tübingen

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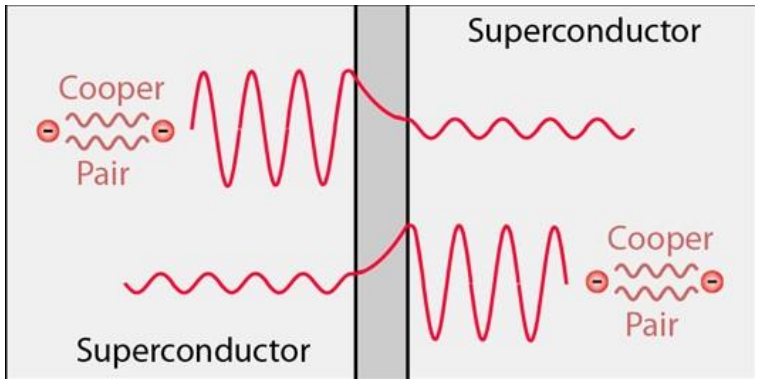
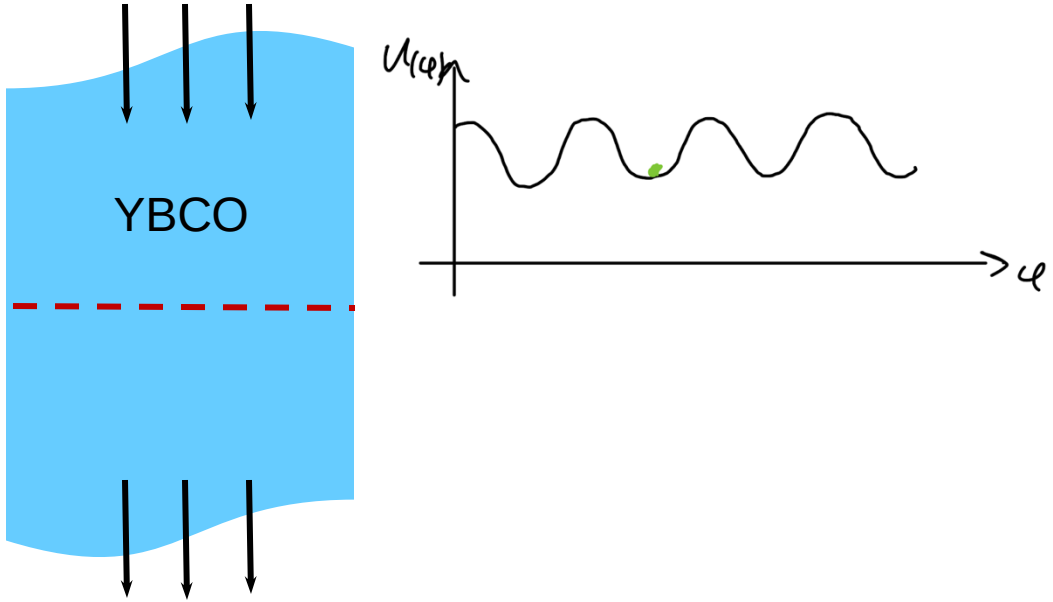
Outline:

1. quick overview of a Josephson junction and a Josephson ratchet (JR)
2. Key property of JR and its operation with AC current and noisy signals
3. Design and Fabrication
4. summary

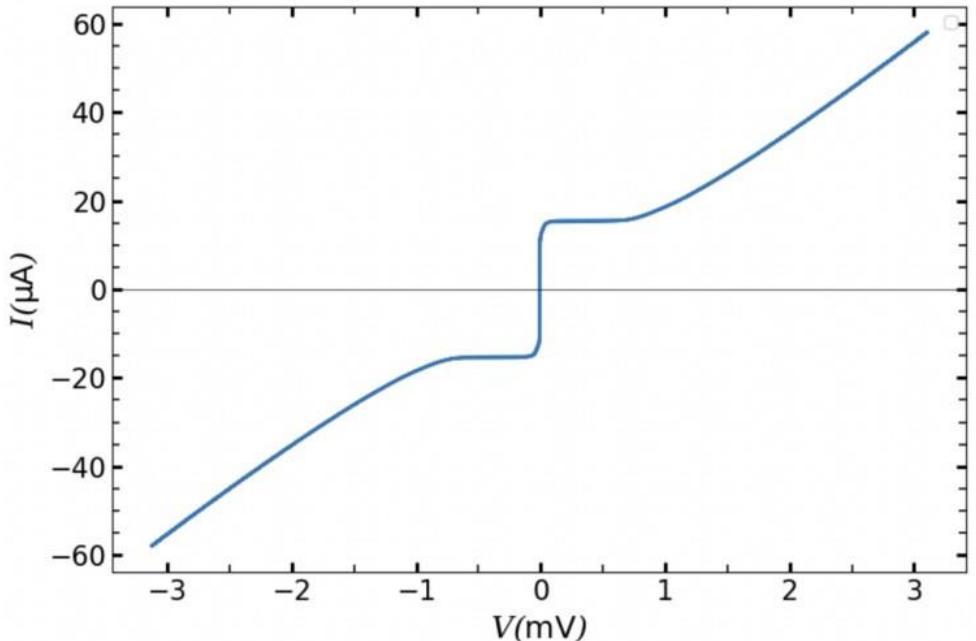
- What is Josephson effect?

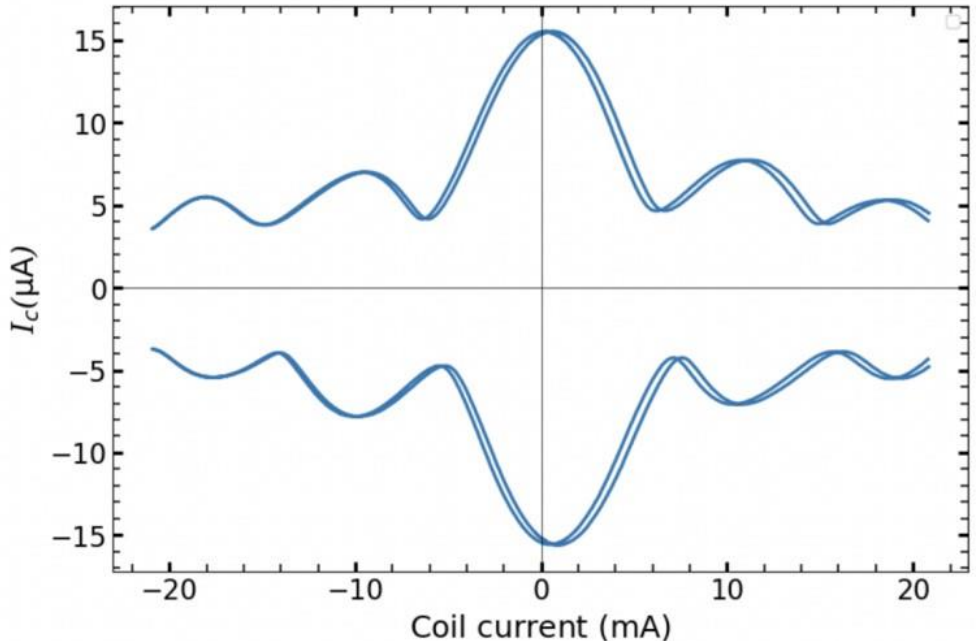


- Schematic of a Barrier Josephson Junction

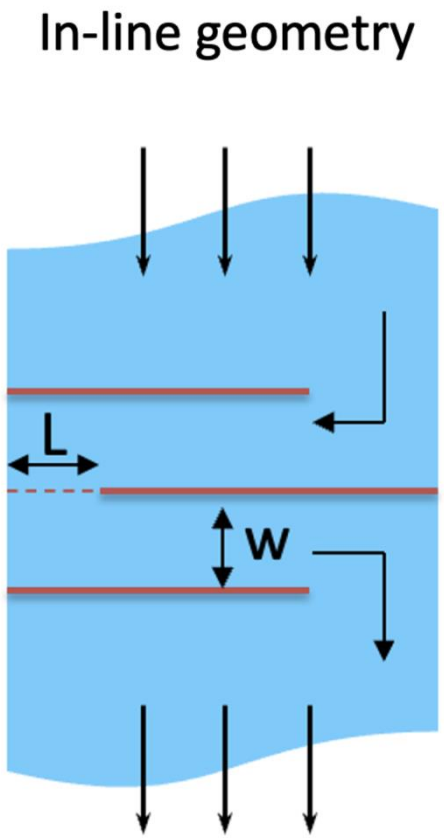


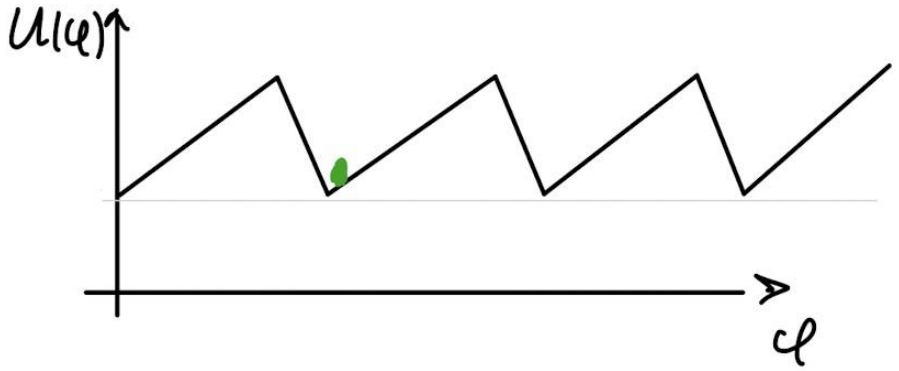
- I-V and I_c(H) characteristic



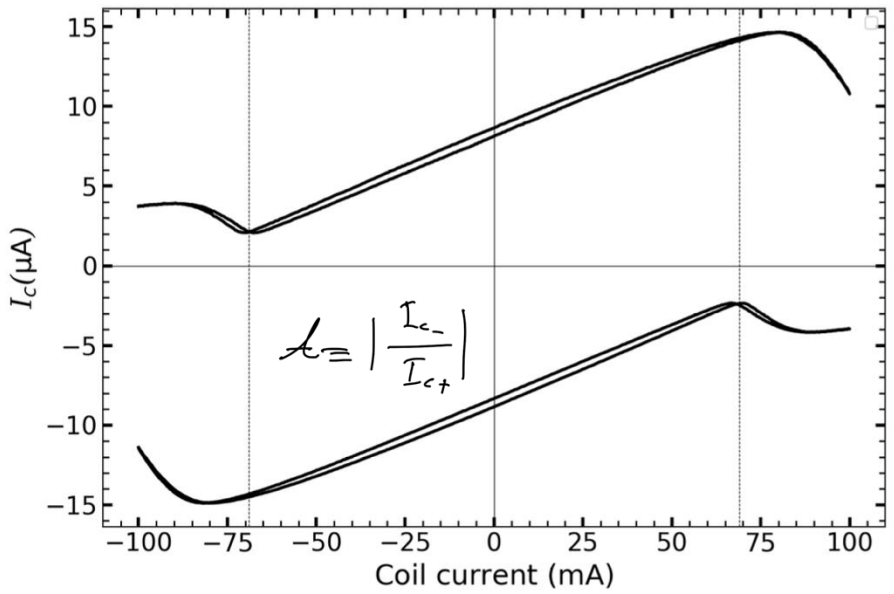


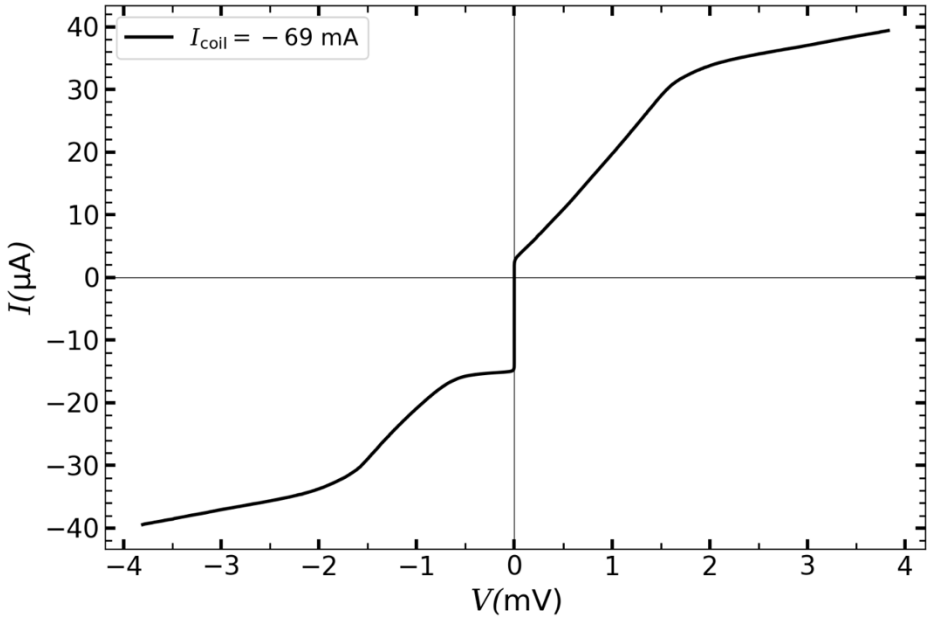
- Schematic Representation of a Josephson Ratchet Device

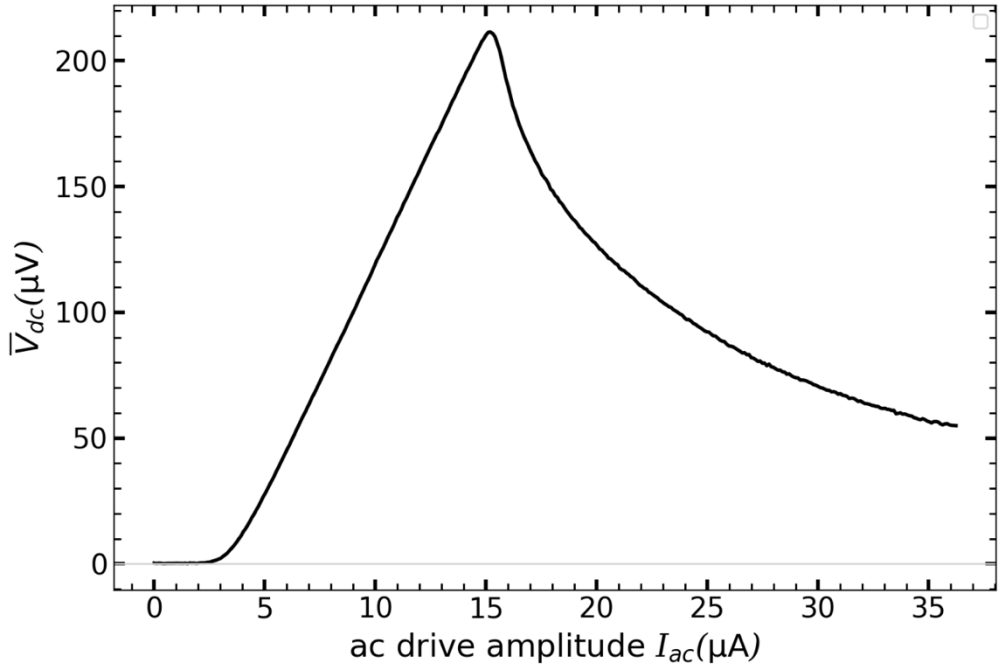




- I-V and $I_c(H)$ characteristic of a Josephson ratchet

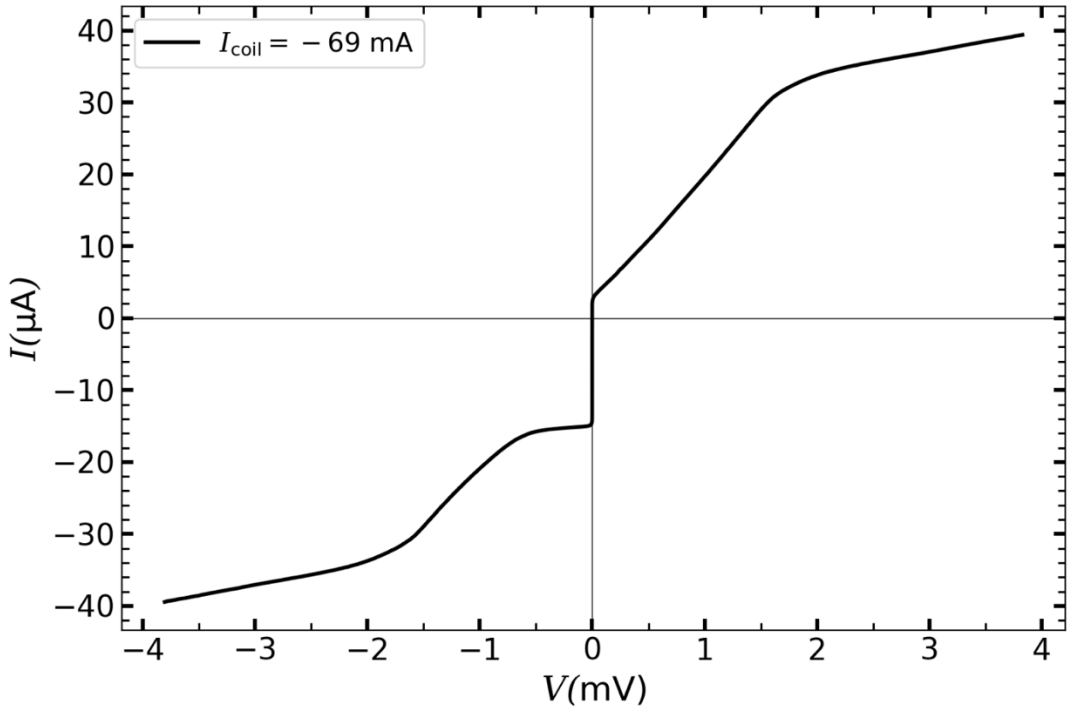


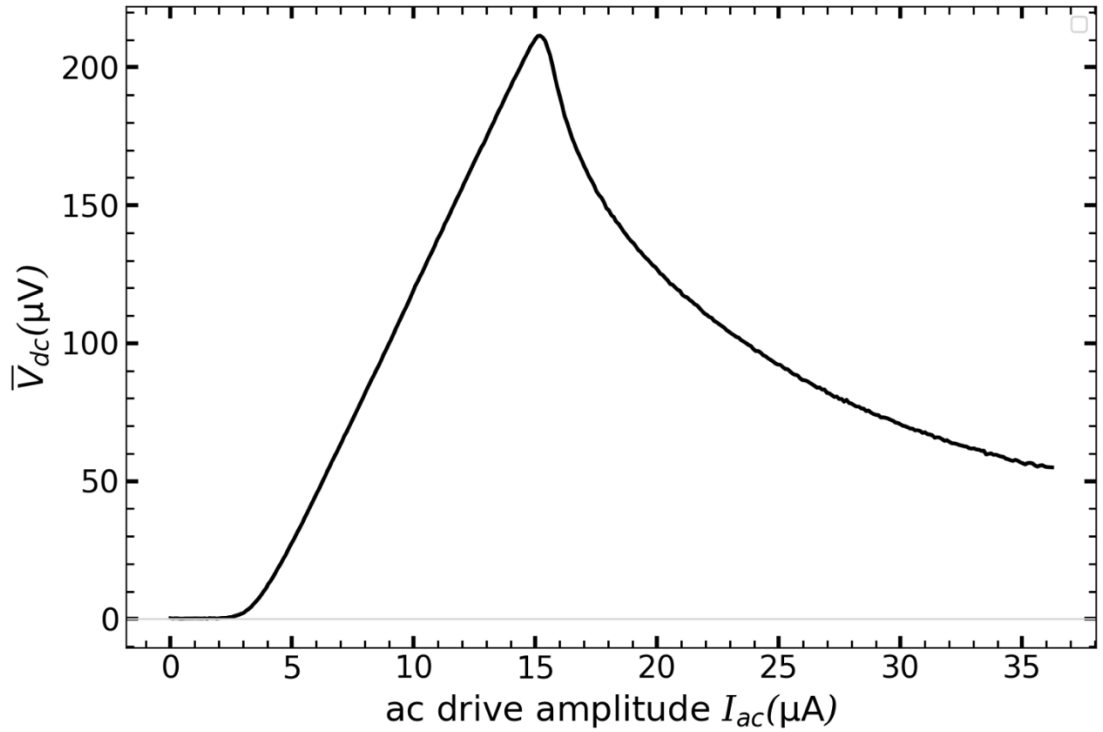




Ratchet #A22

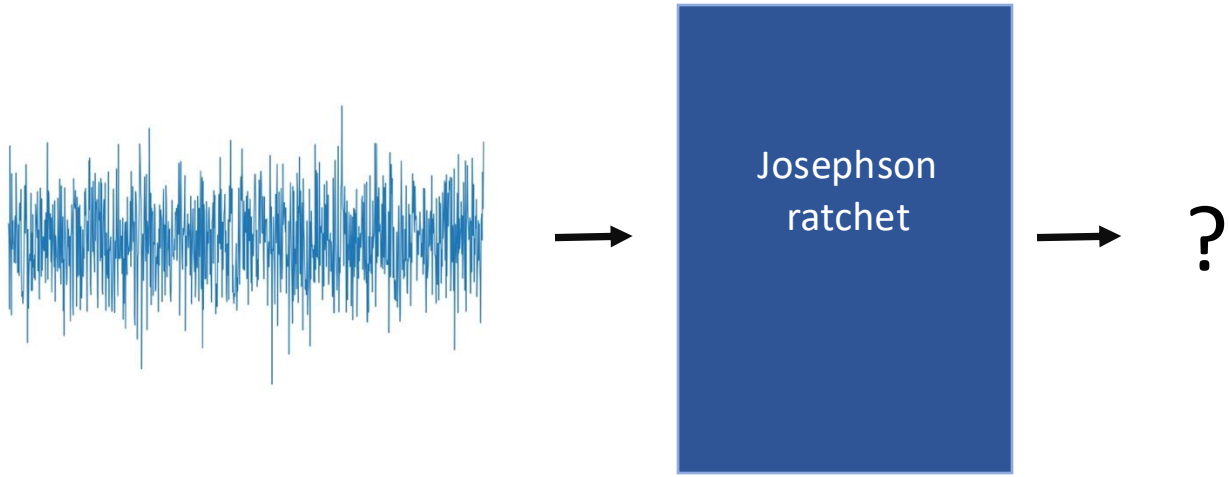
- a key property of such a device is that it can be used as a rectifier.



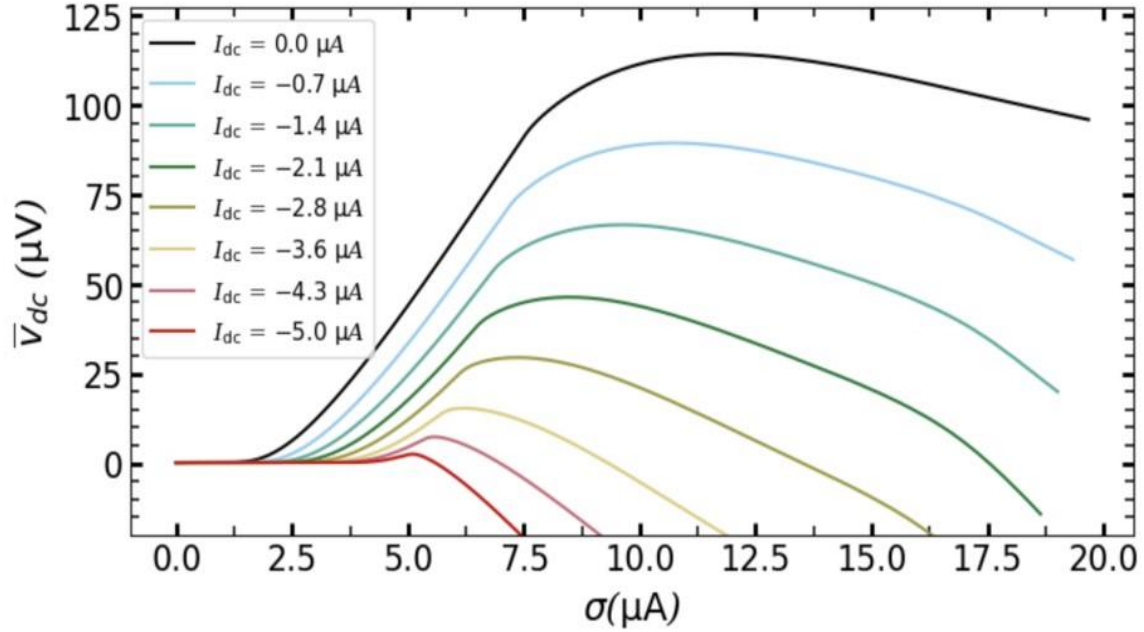


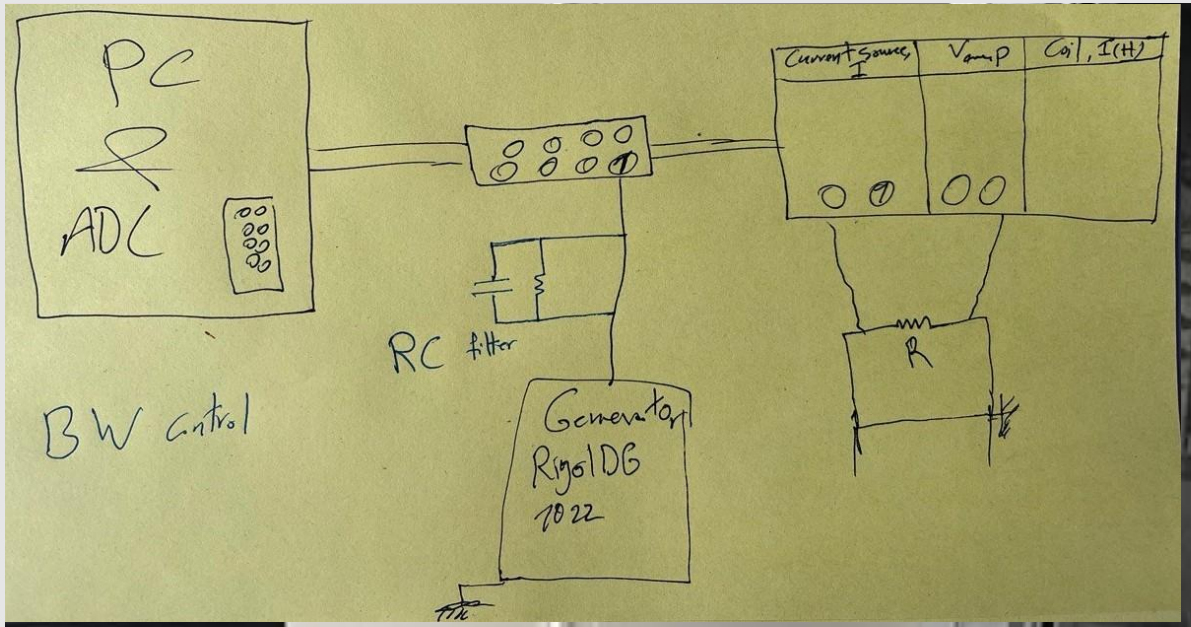
- How can the system rectify **noises** instead of AC derive to DC voltage?
- In general noises could be classified into two categories: **External** and **Internal** noises.

A) External Noise:

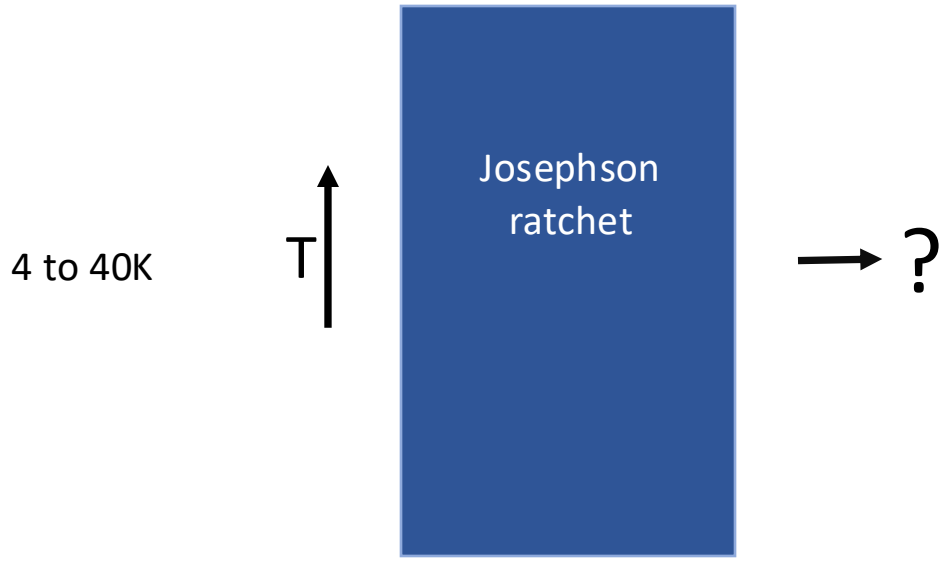


- Rectified Voltage Simulation from Noisy Signal and Experimental Expectations



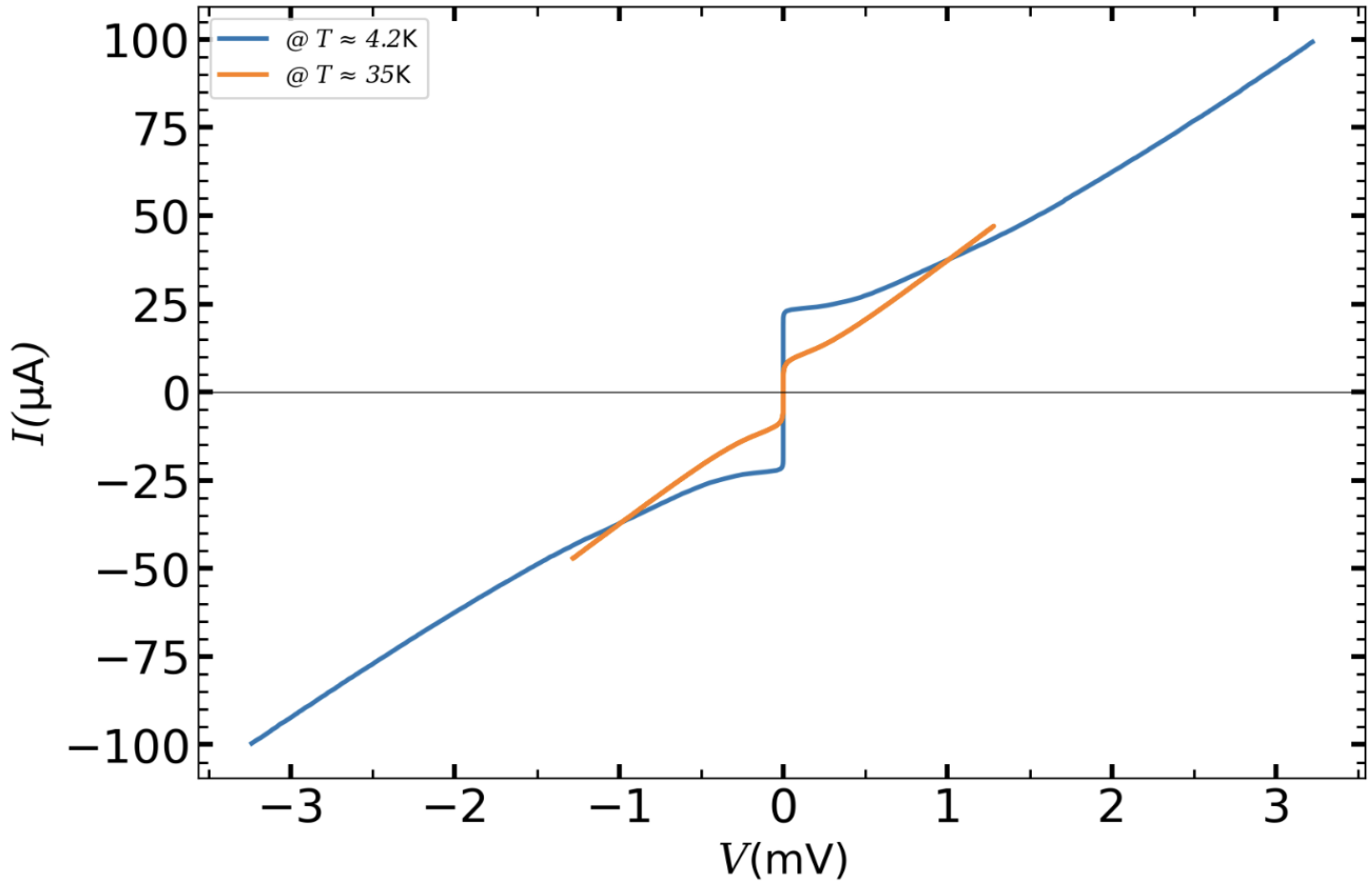

PC
&
ADC
BW control
RC filter
Generator
Rigol DG
1022
Current Source
I
Vamp
Coil, I(H)
R

B) Internal Noise:



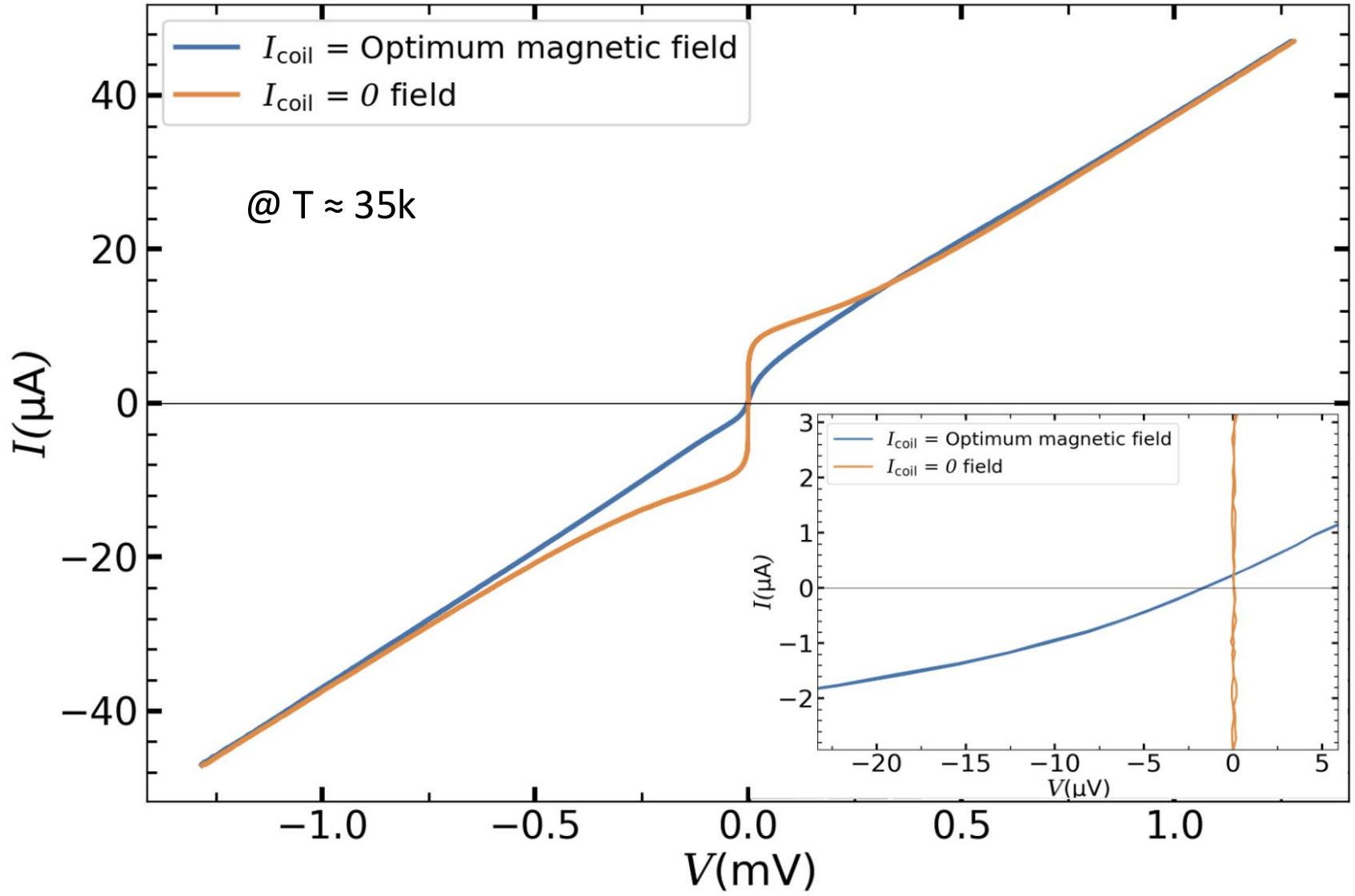
- Increasing temperature increases thermal energy, and this enhances the random fluctuations in the system.
- Thermal fluctuations refer to the random changes in the system's properties e.g. moving and interacting the particle in a random and unpredictable manner.
- In our system e.g., this fluctuation could lead in changing the phase in supercurrent relation due to the thermal energy.

- An initial experimental result of intrinsic noise for a Josephson ratchet system back to my master thesis:

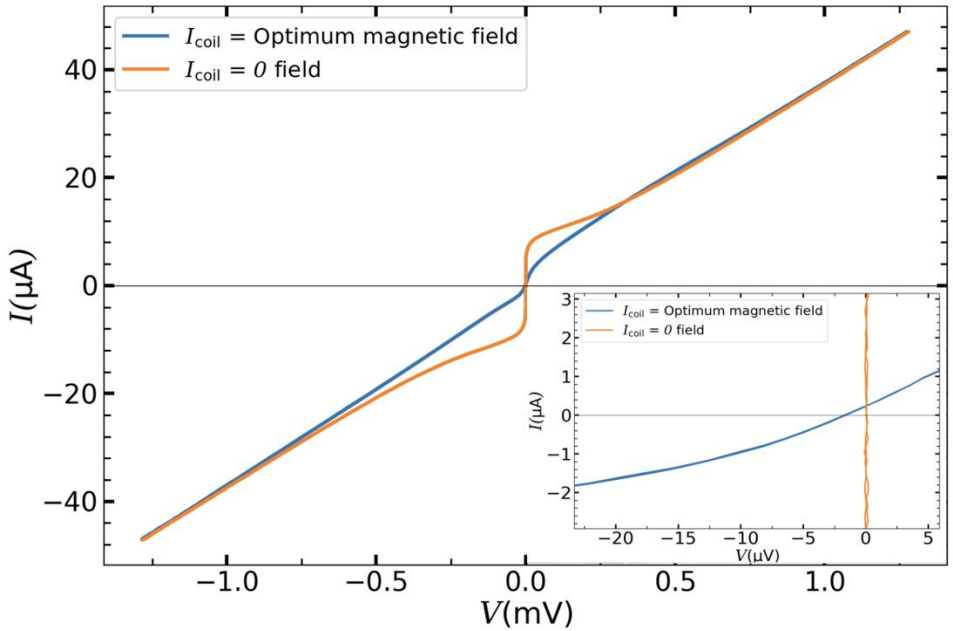


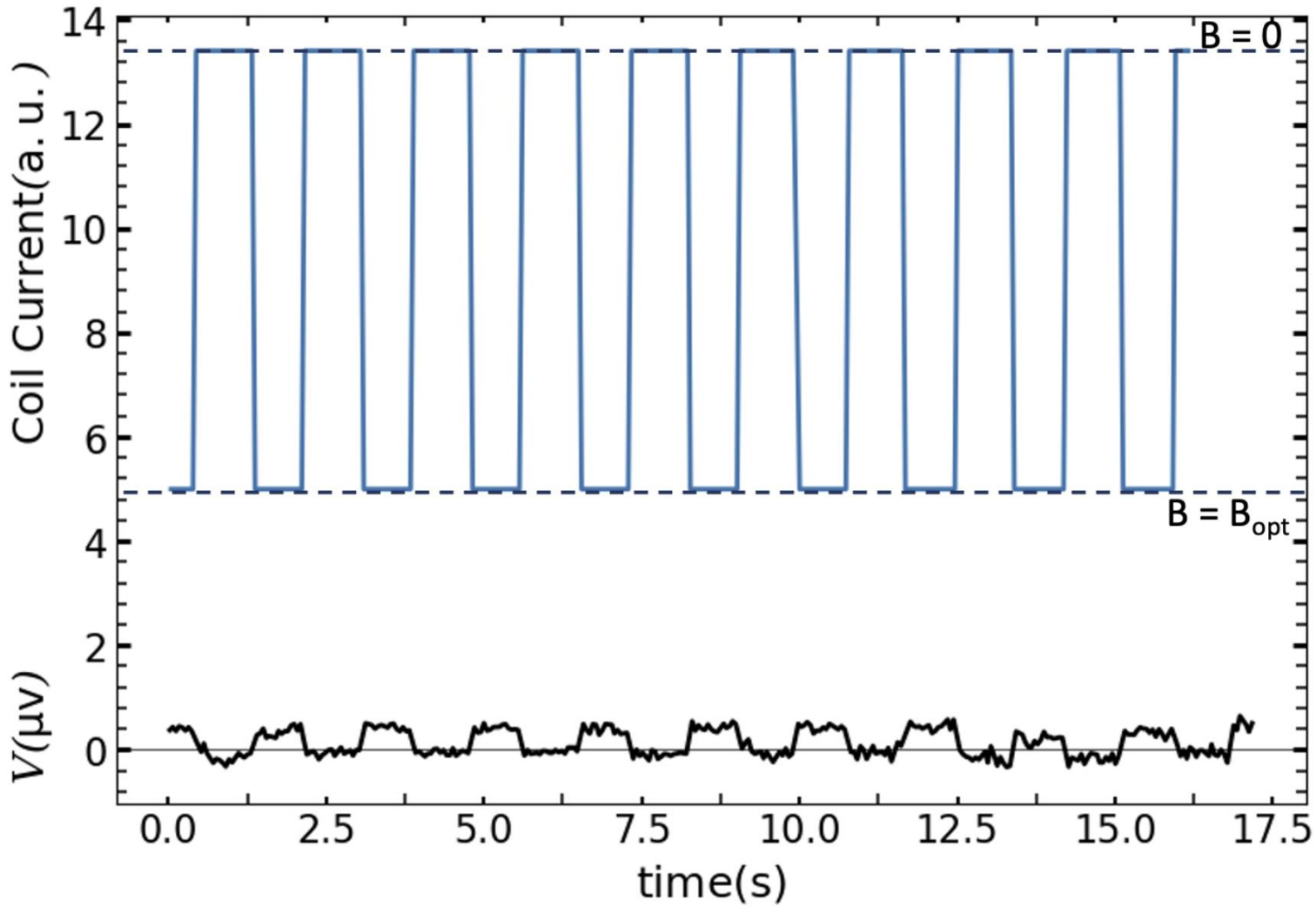
Ratchet #A15

Ratchet #A15

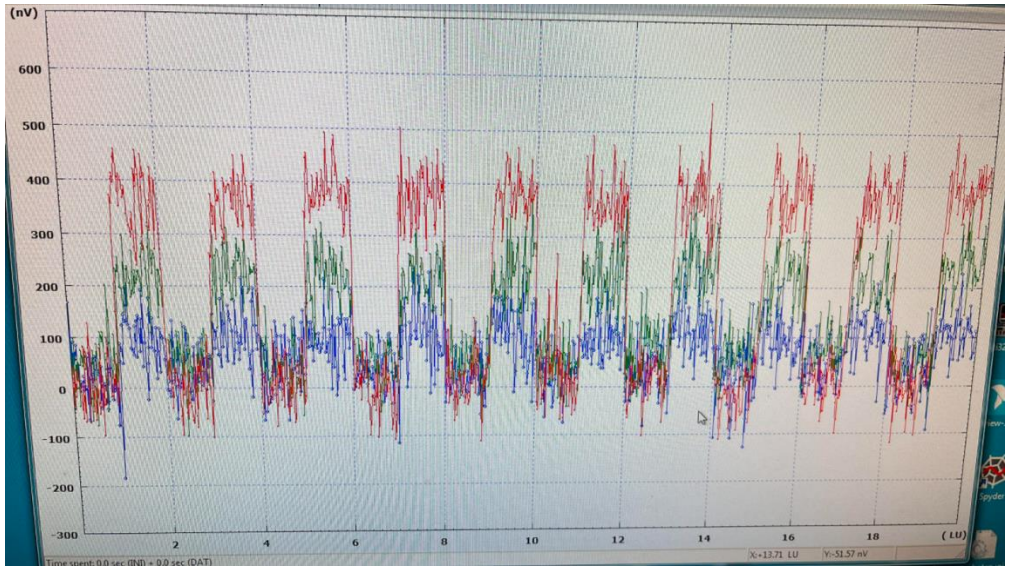

I_{coil} = Optimum magnetic field
I_{coil} = 0 field
@ T ≈ 35k
40
20
0
−20
−40
I(μA)
−1.0
−0.5
0.0
0.5
1.0
V(mV)
3
2
1
0
−1
−2
−20
−15
−10
−5
0
5
V(μV)

Ratchet #A15


I_{coil} = Optimum magnetic field
I_{coil} = 0 field
$I(\mu A)$
$V(mV)$
$V(\mu V)$


B = 0
B = B_{opt}
Coil Current(a.u.)
$V(\mu v)$
time(s)

Ratchet #A17



Some of my naive Proposal for causing this Rectification Effects:

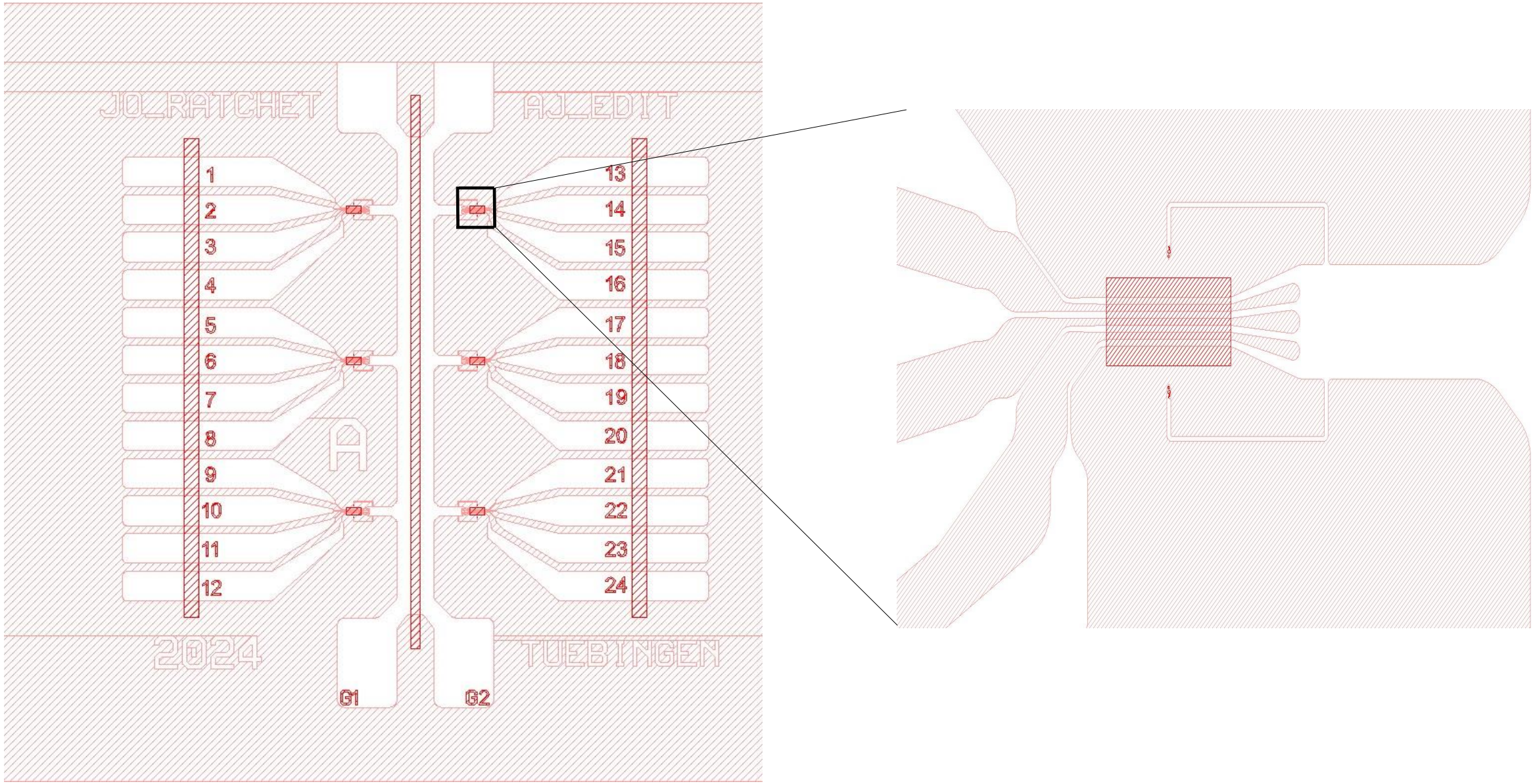
1. The increased rectified voltage with temperature would tell us that the system might be driven further out of equilibrium as temperature increases. Therefore, the thermal fluctuation is allowed to be rectified into the DC voltage.

2. Thermal fluctuations might depinning vortices★ more quickly at higher temperatures, contributing to rectified DC voltage.

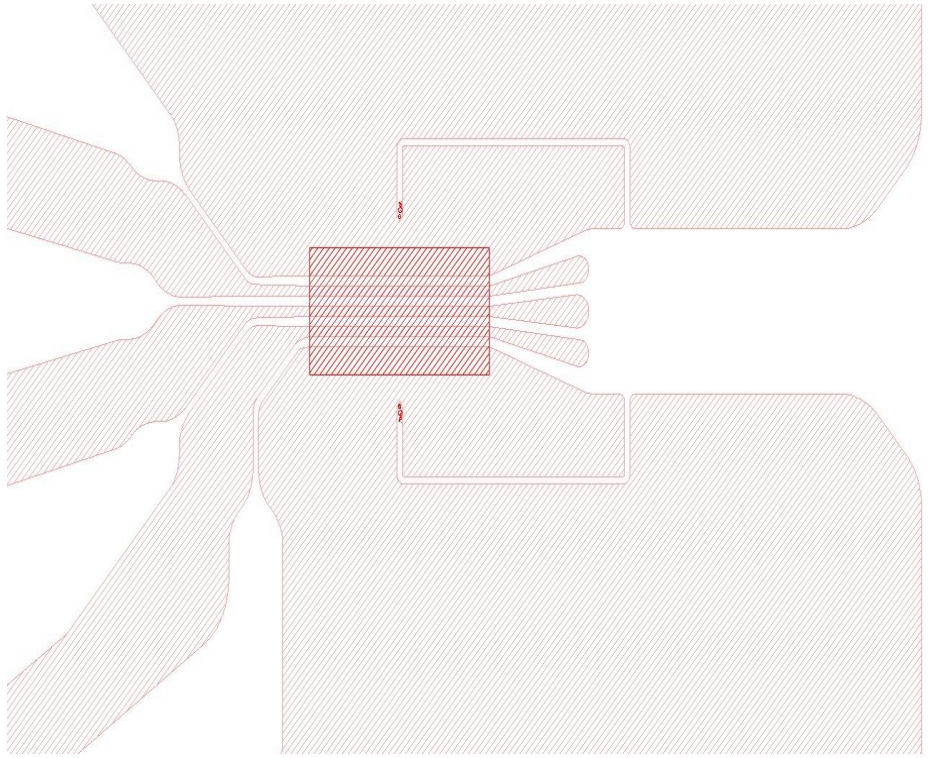
★ **Vortex Pinning**: Vortices are pinned by defects and inhomogeneities in type-II superconductors to prevent moving within the bulk of the superconductor.

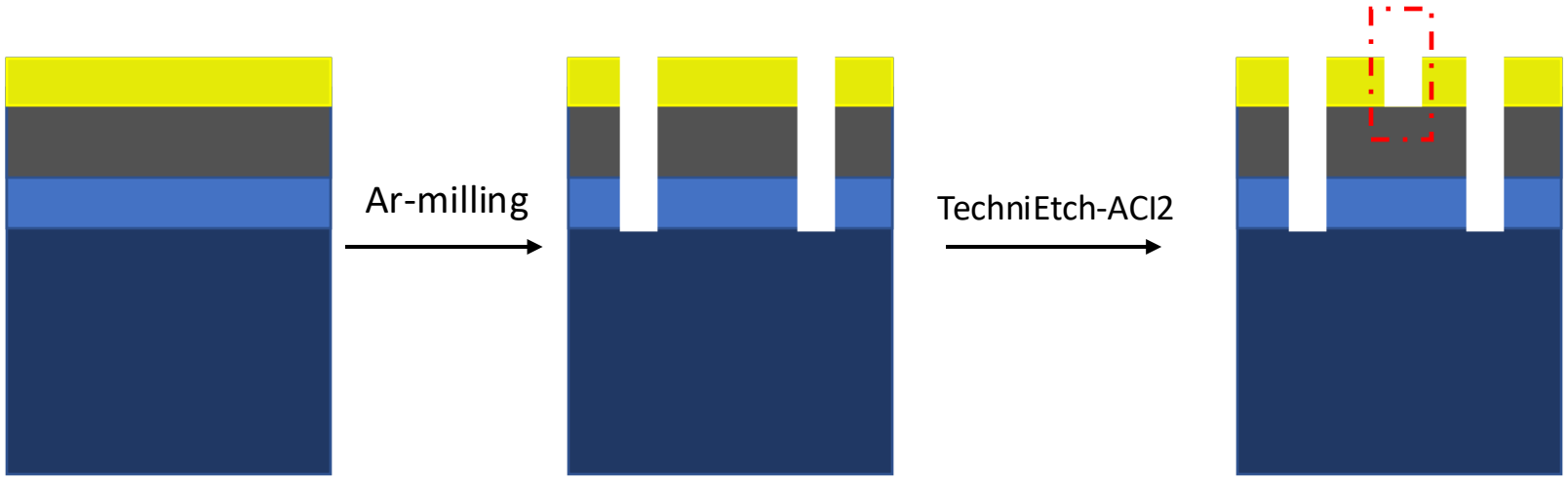
Design and Fabrication

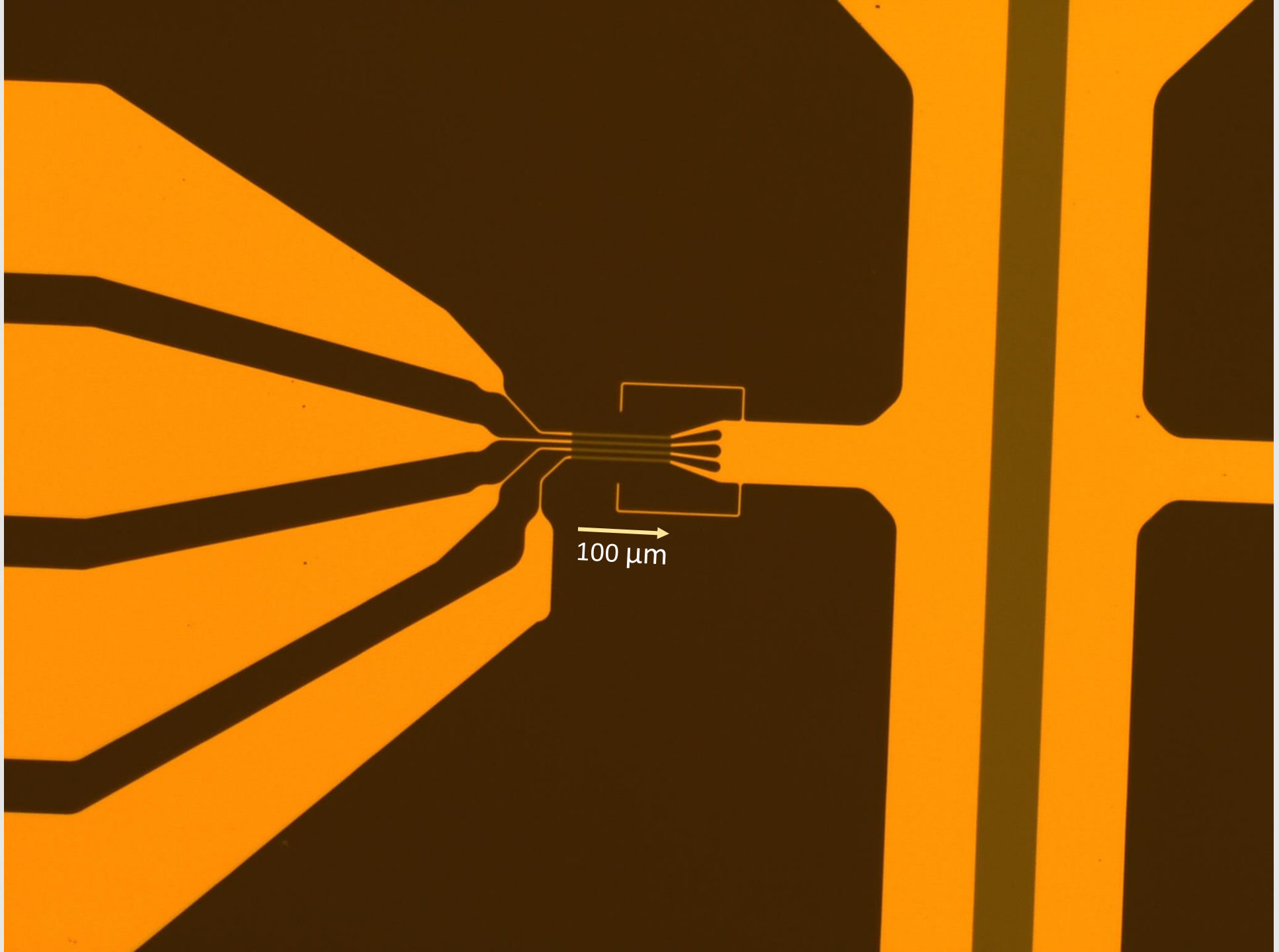
- A complete modification and redesigning of a layout to be optimized for the He-FIB operator.

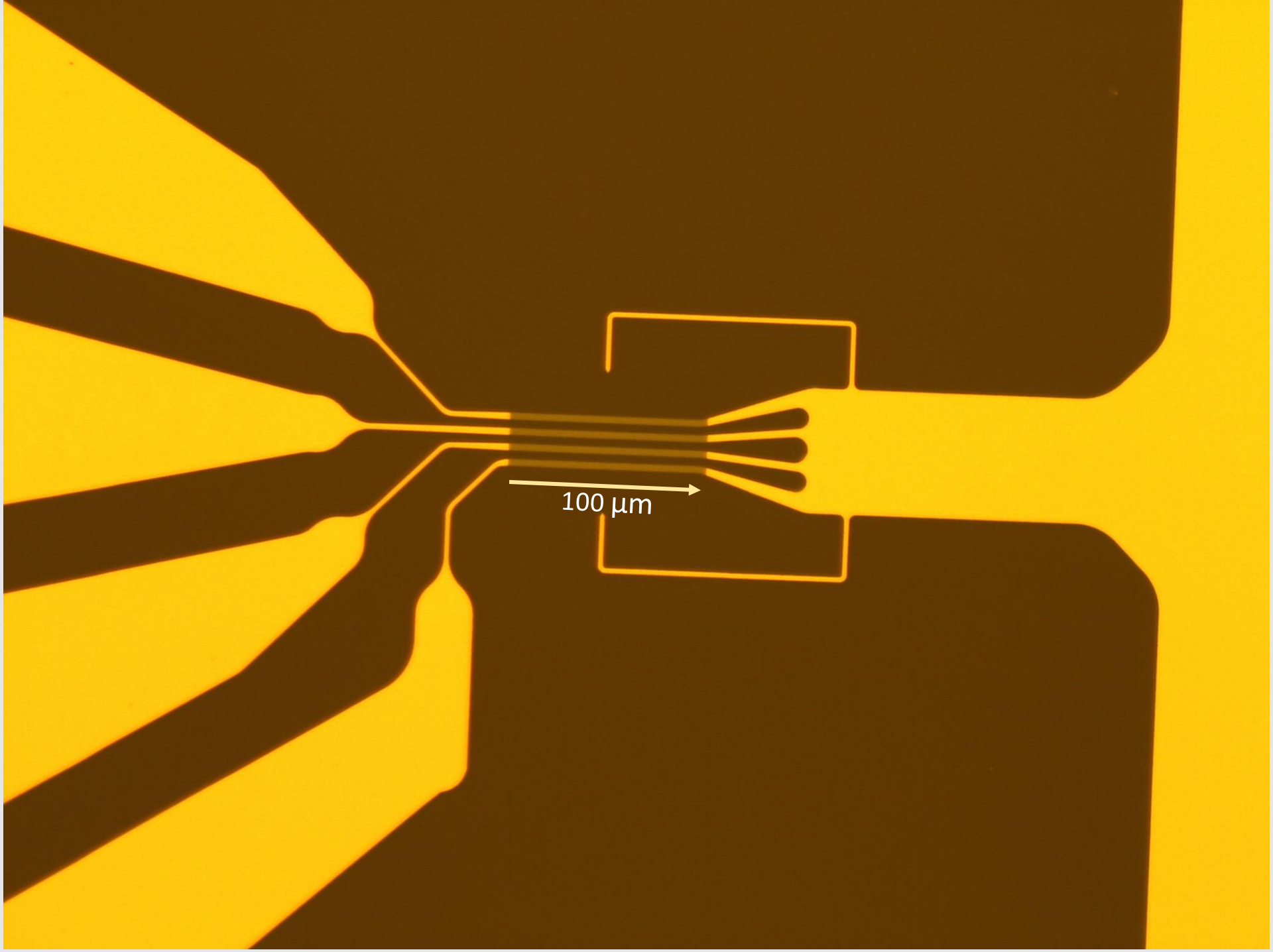


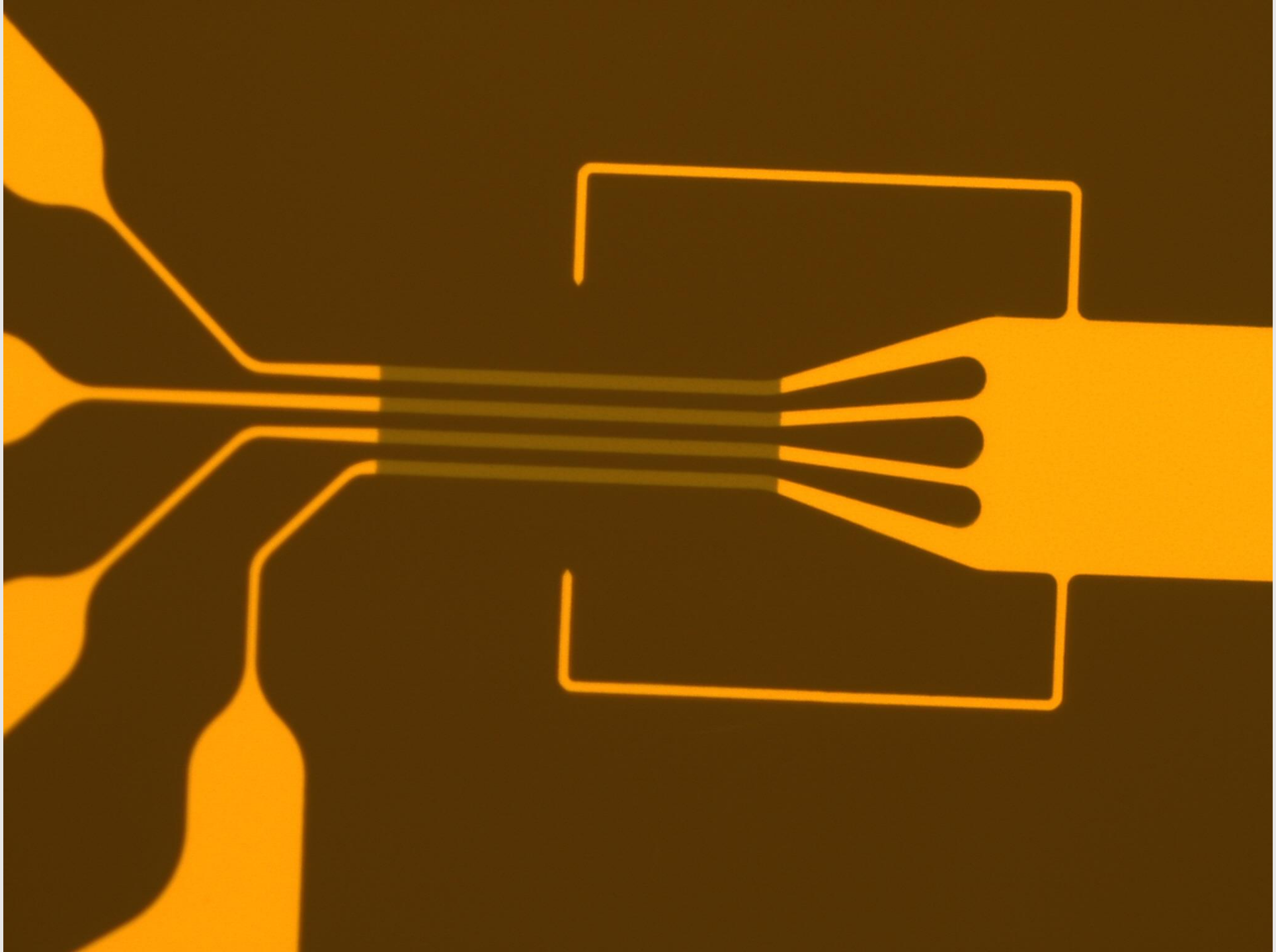

Au (20nm)
YBCO (30nm)
CeO2 (30nm)
Substrate (LSAT)

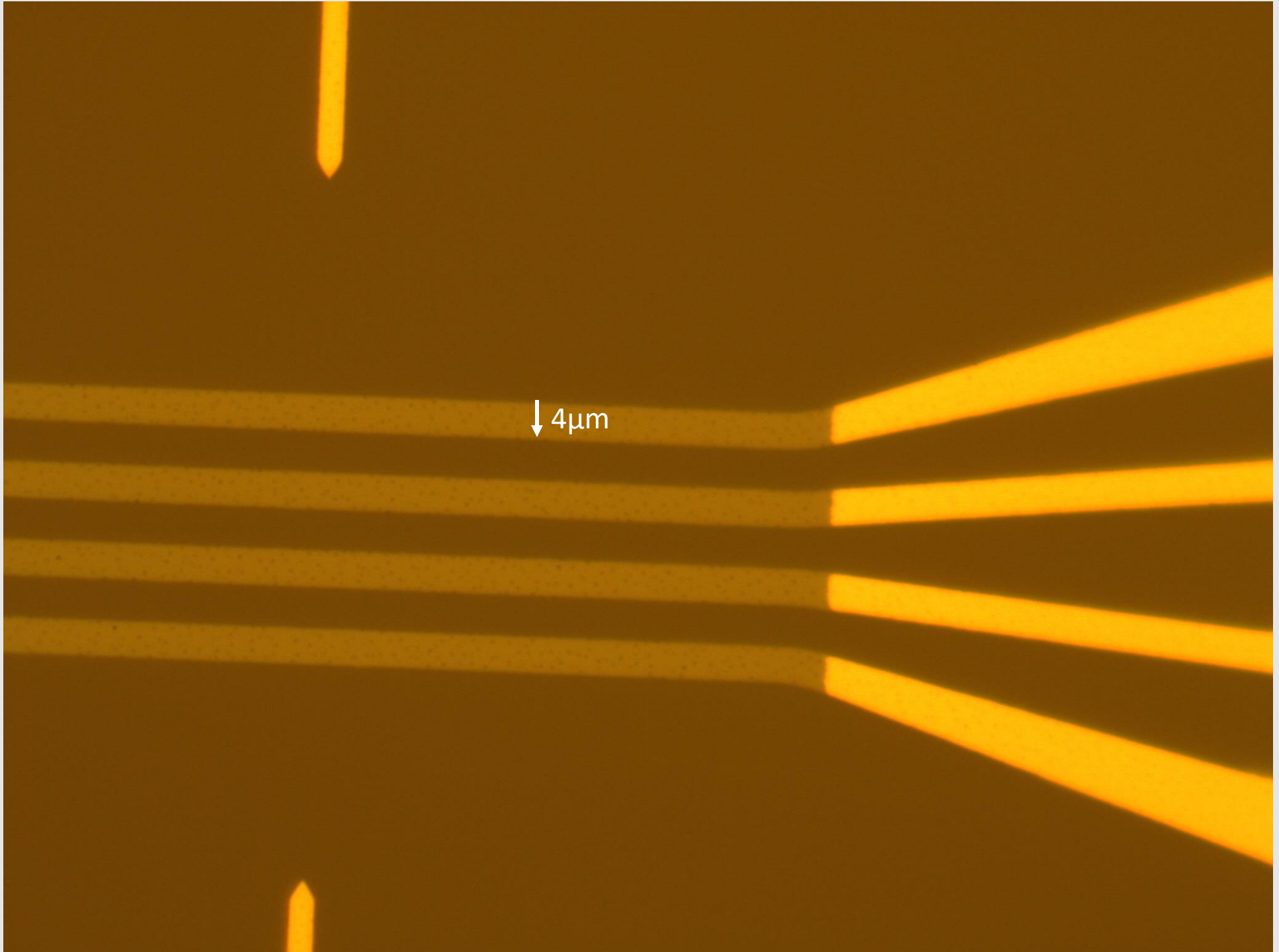


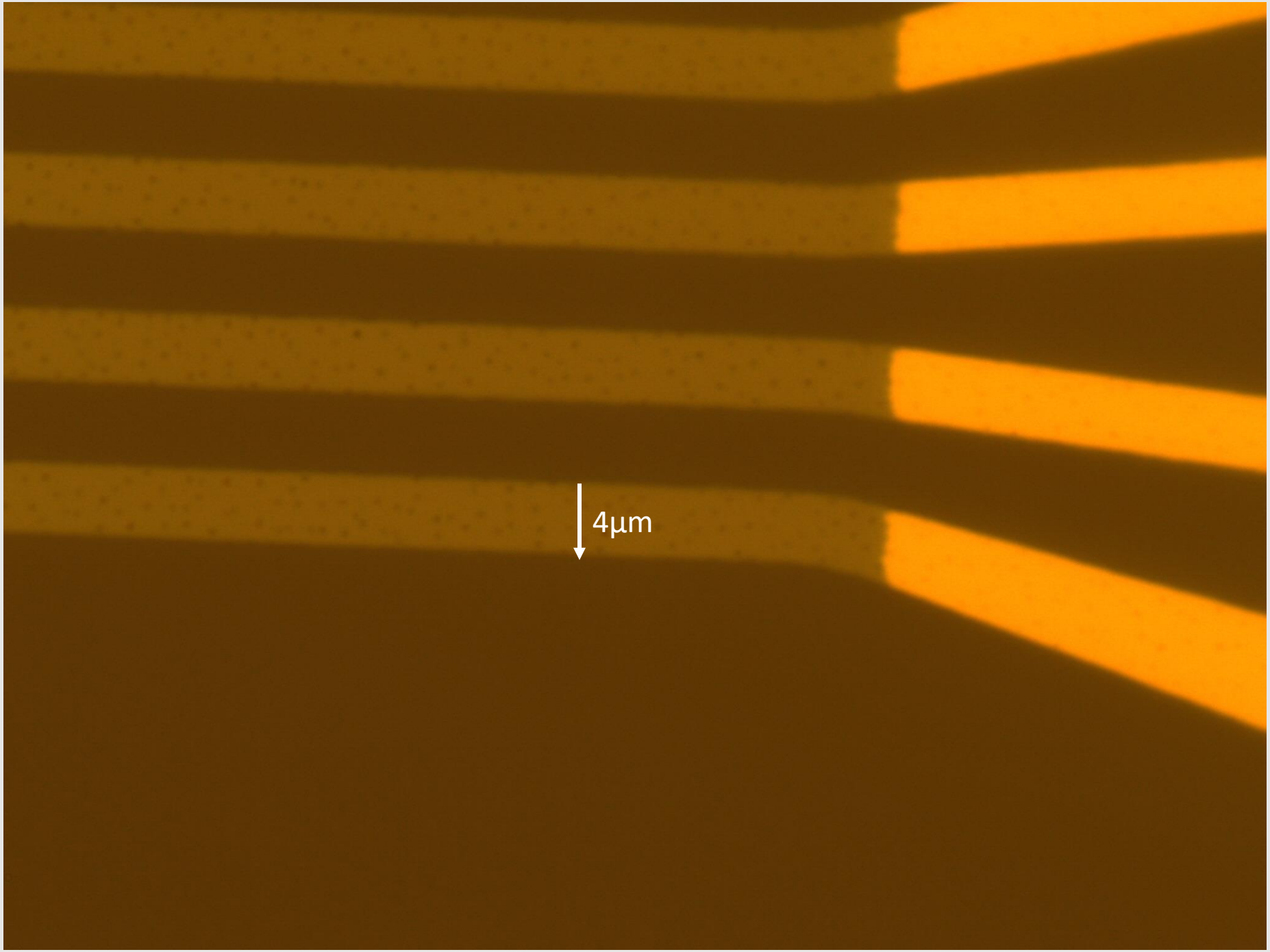

Ar-milling
TechniEtch-ACl2


100 µm

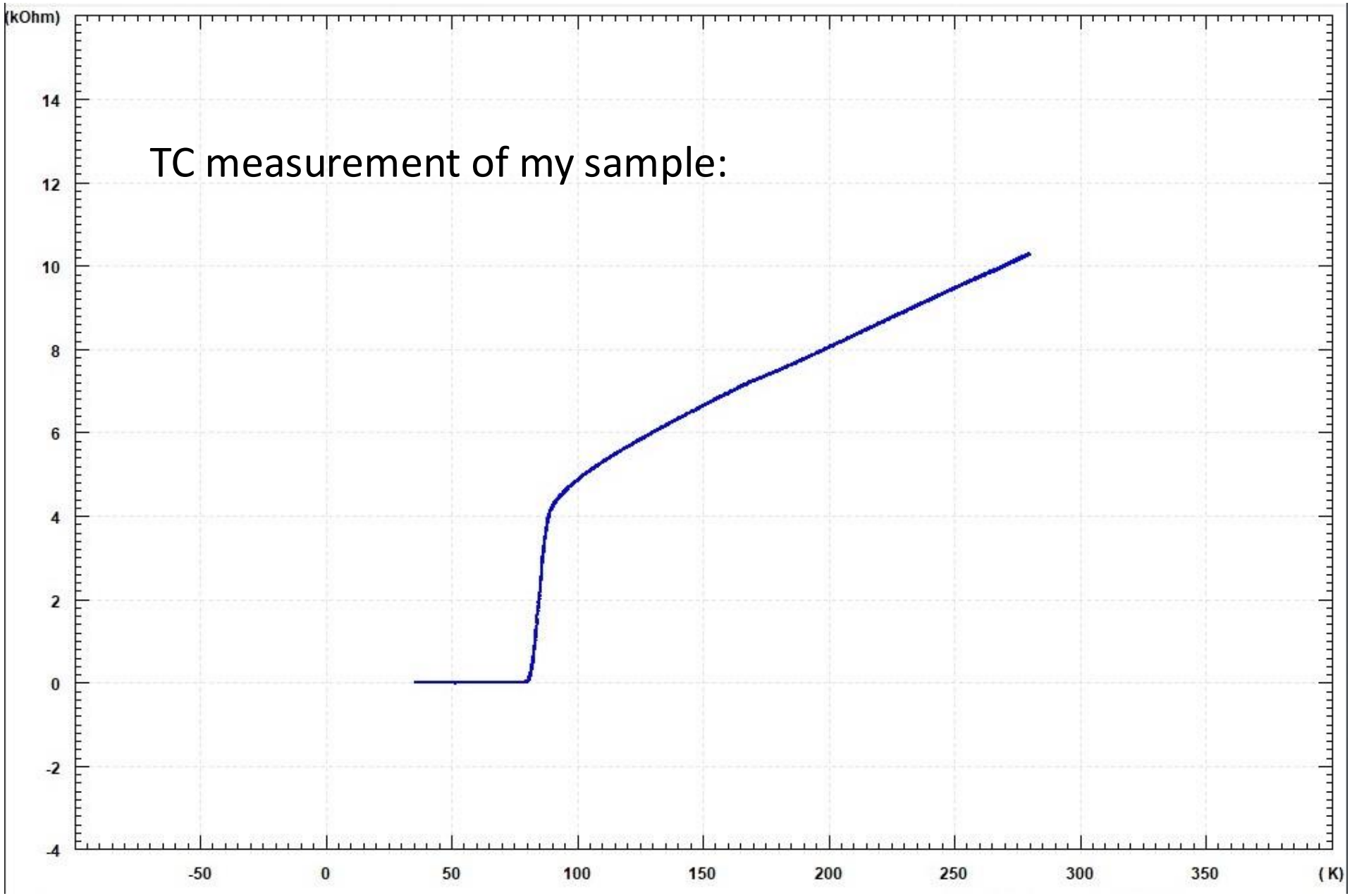

100 µm




4µm


4µm

TC measurement of my sample:



Summary:

- A brief review of Josephson ratchet
- Josephson ratchet operation
- Showing off some of my design and fabrication skill