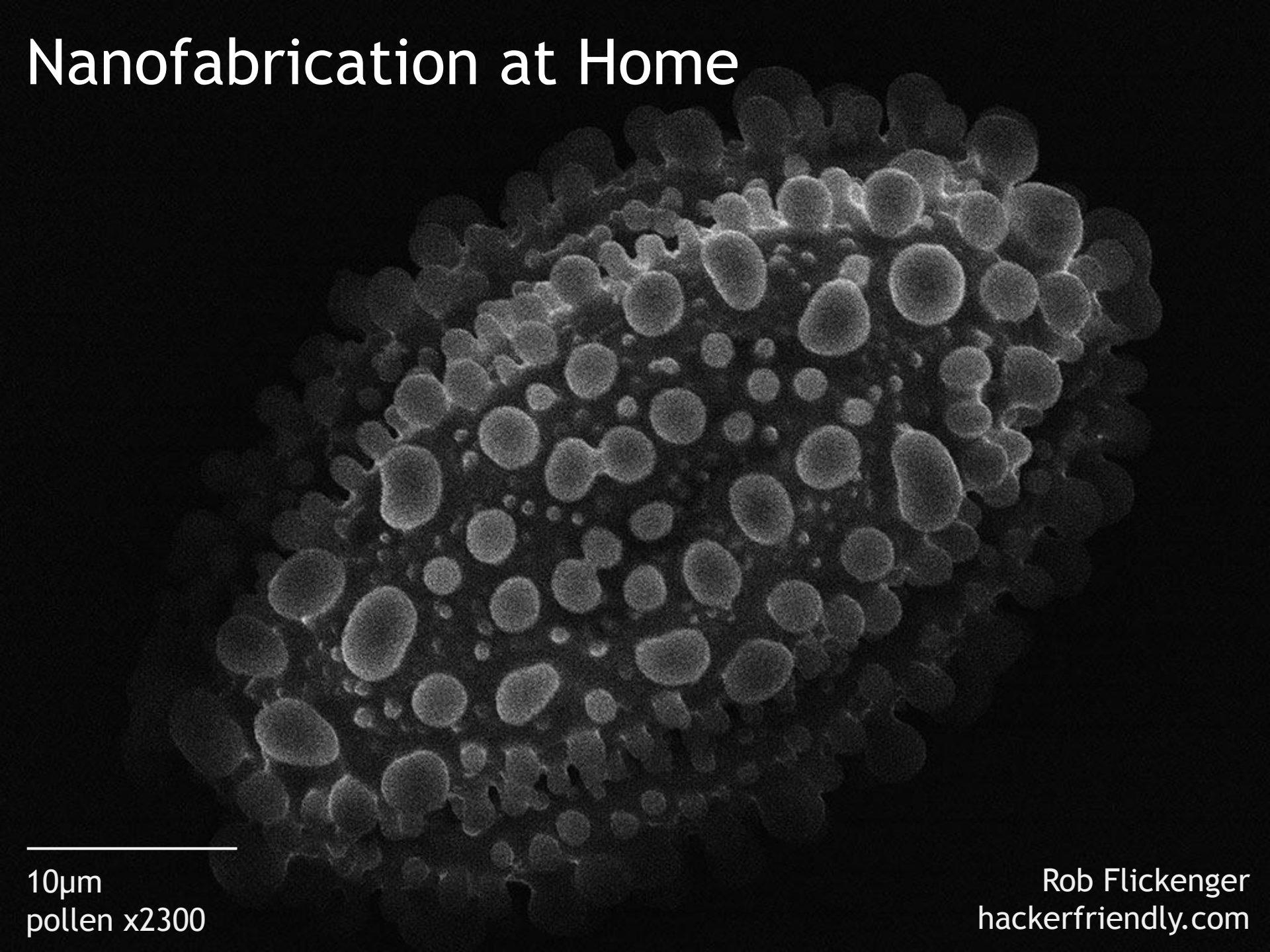
Nanofabrication at Home

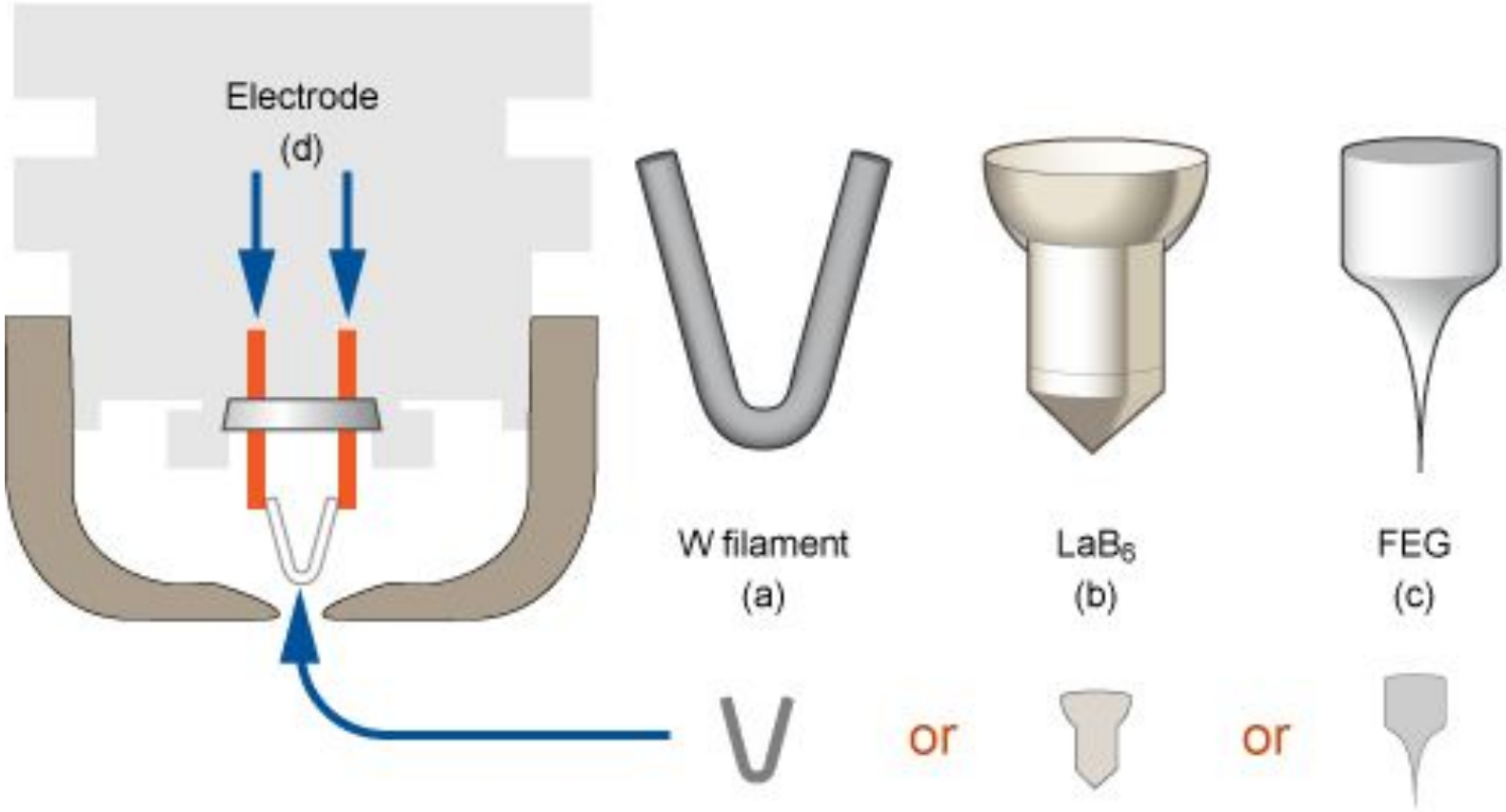


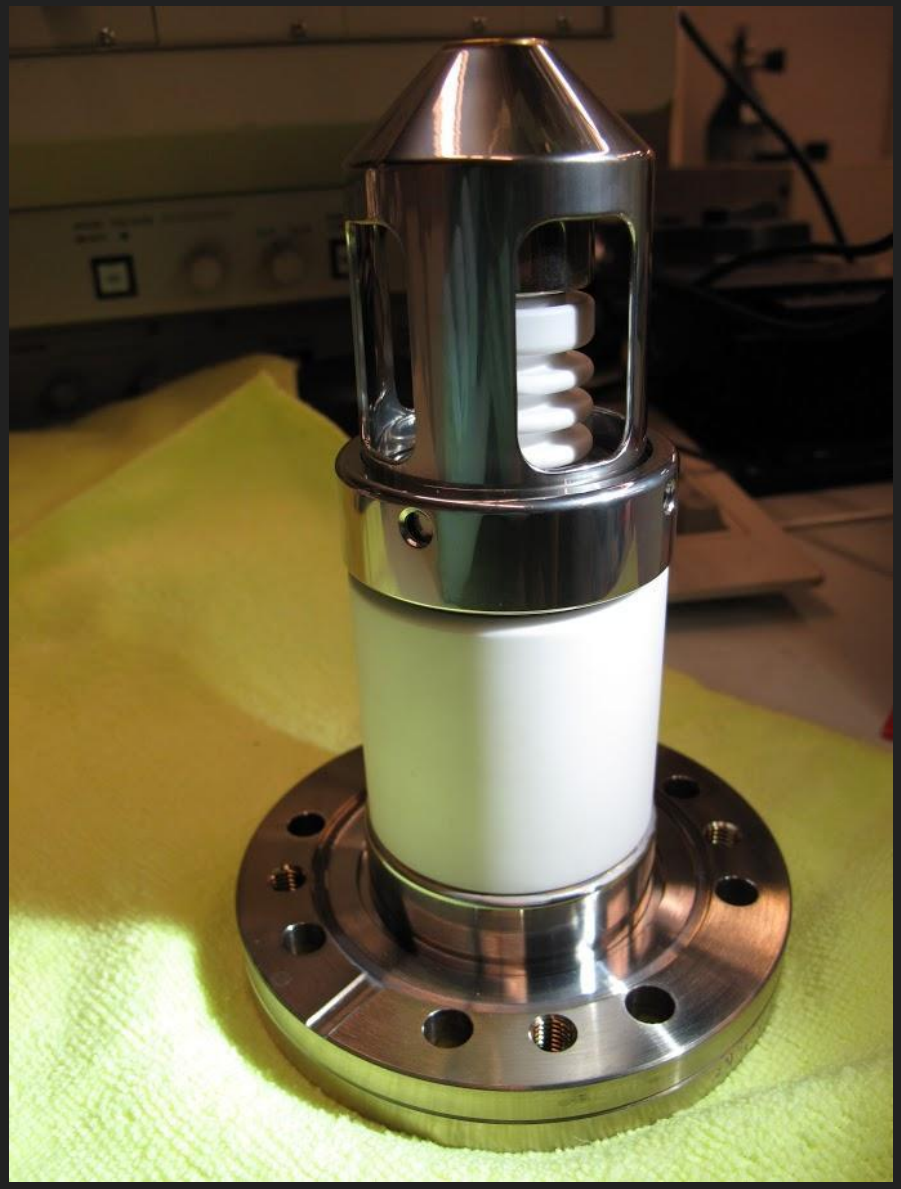
10µm
pollen x2300

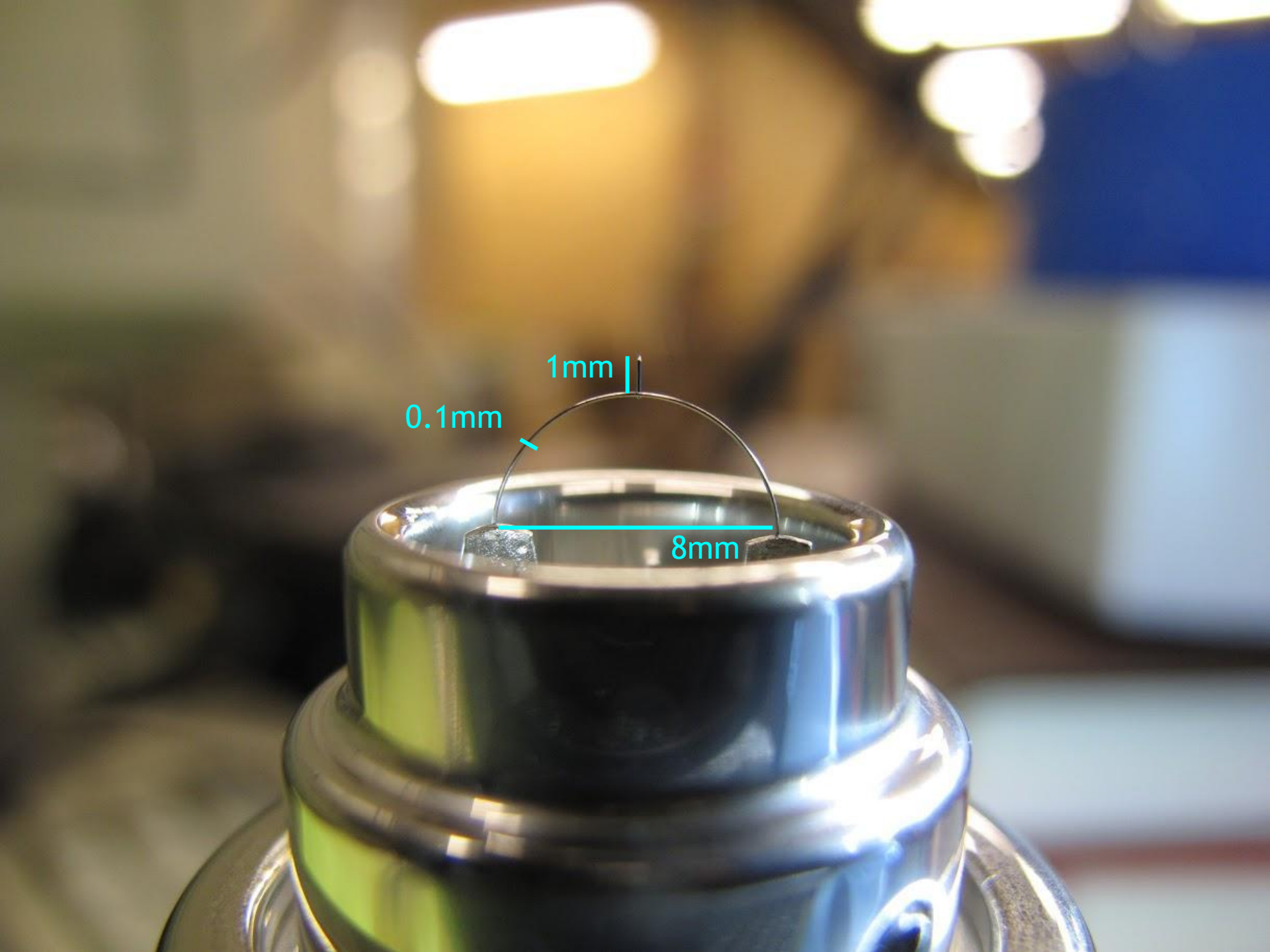
Rob Flickenger
hackerfriendly.com

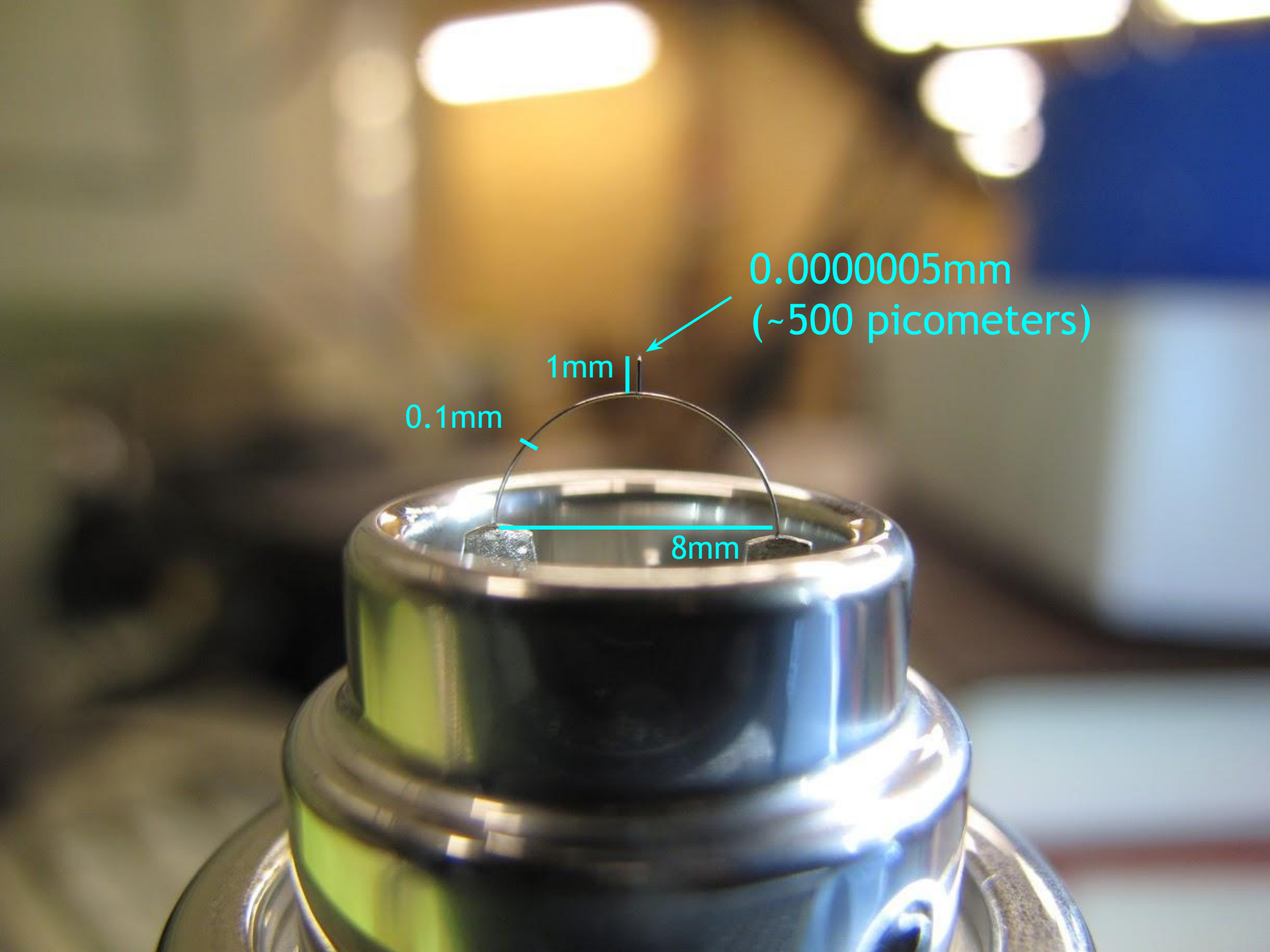
Milly is a JEOL JSM-6320F Scanning Electron Microscope Made in 1980

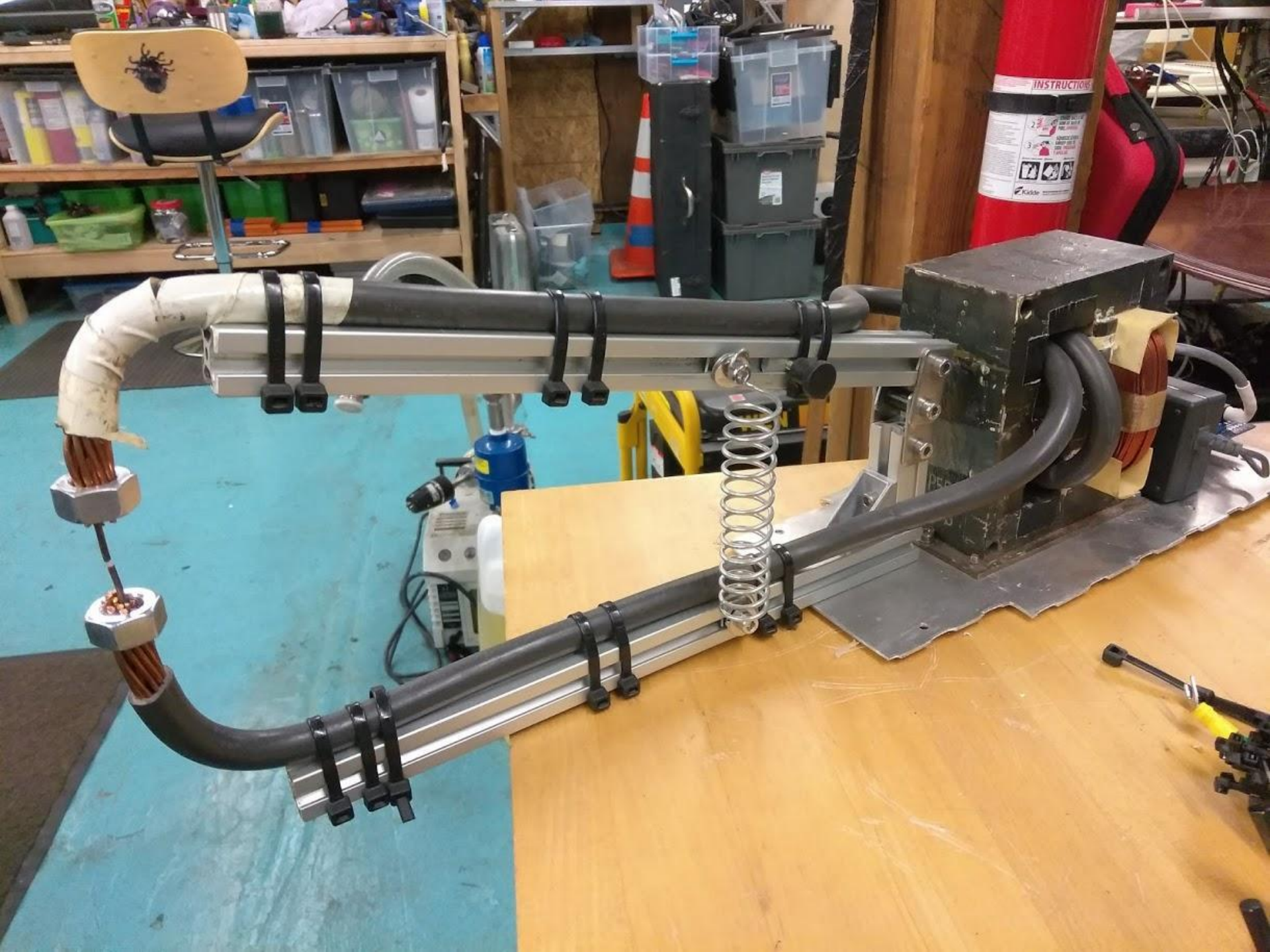
F is for FEG: Field-emission Electron Gun
Cold cathode tungsten crystal

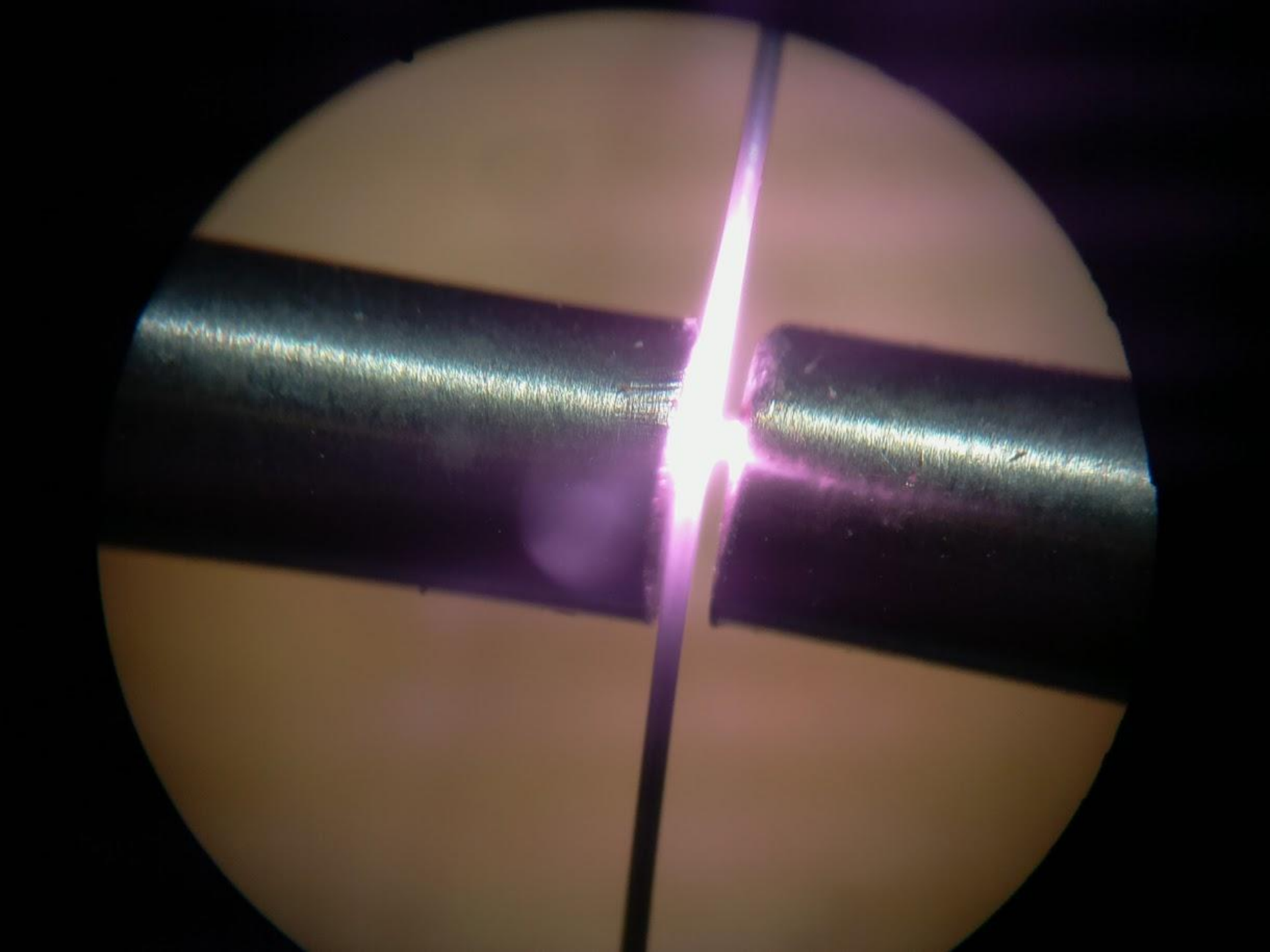


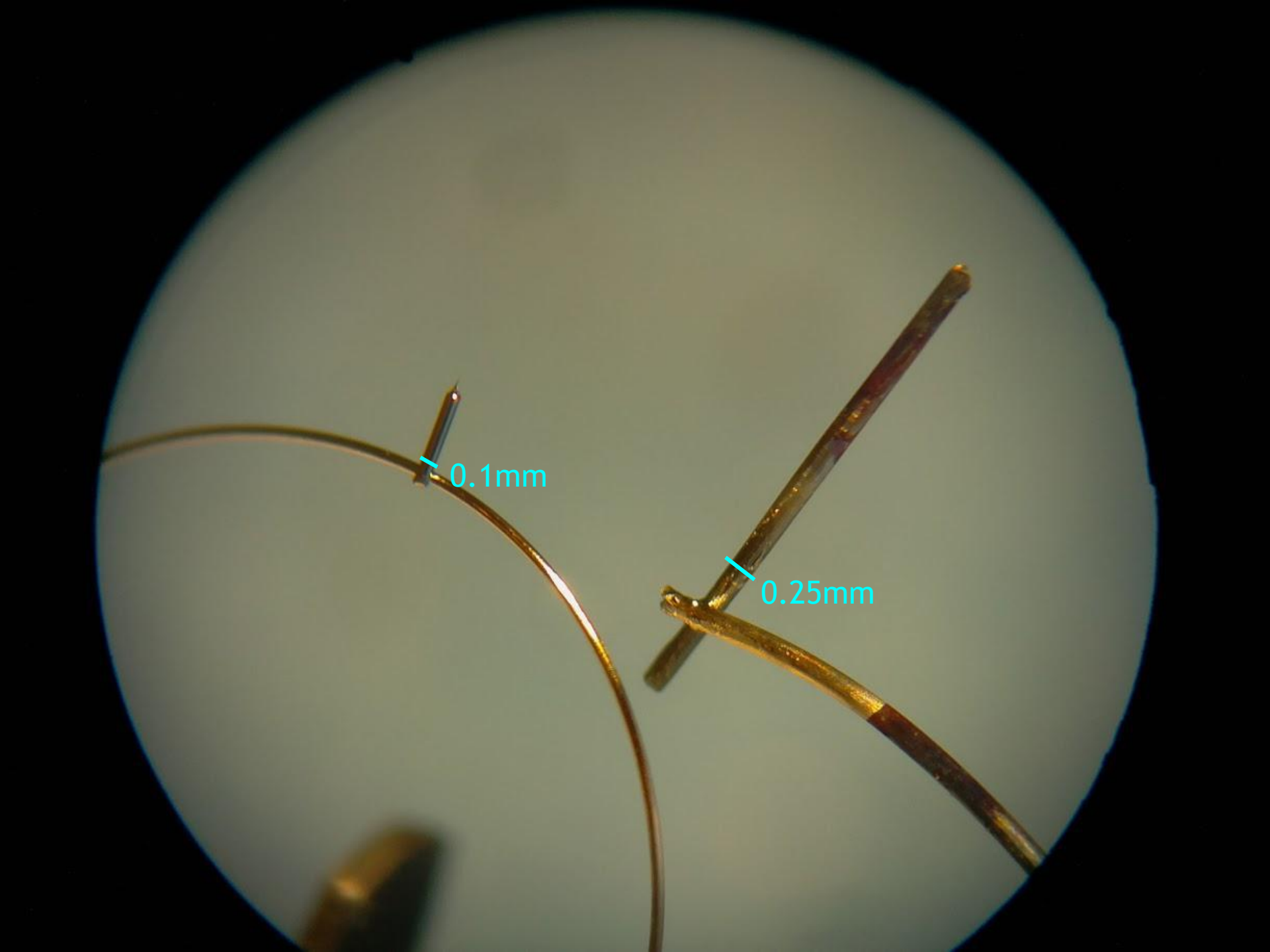



1mm
0.1mm
8mm


0.0000005mm
(~500 picometers)
1mm
0.1mm
8mm


INSTRUCTIONS




0.1mm
0.25mm

eBay to the rescue

Thanks, drone enthusiasts!

“Battery tab” welder

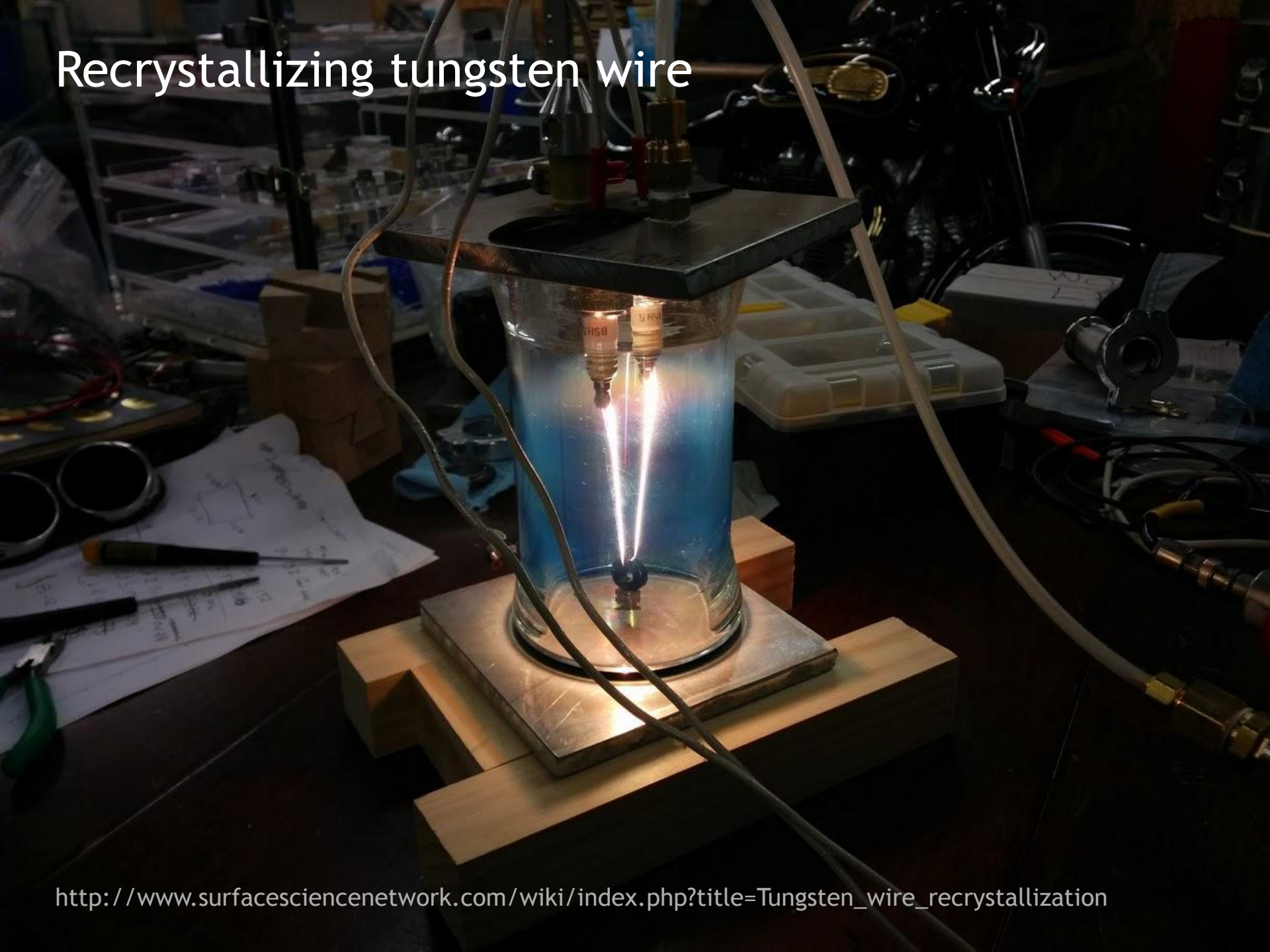
Much faster rise time

Better current control

< $200 on eBay

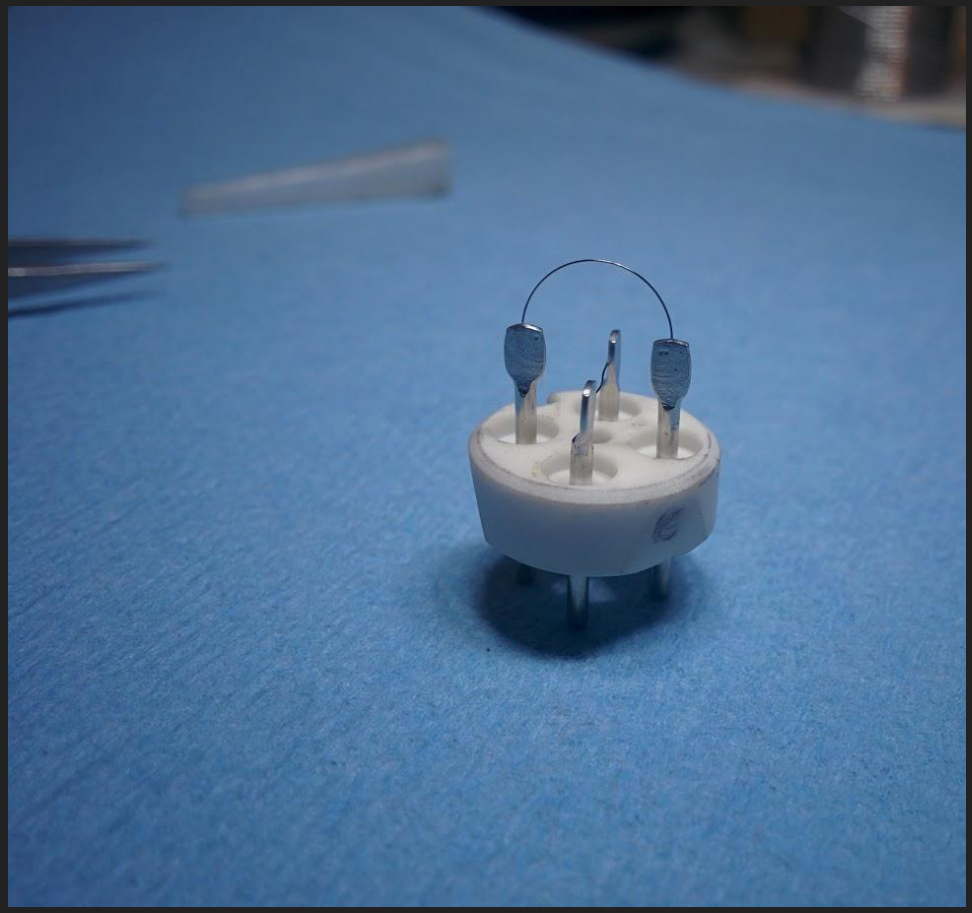
Only had to take it apart once (so far) for repair

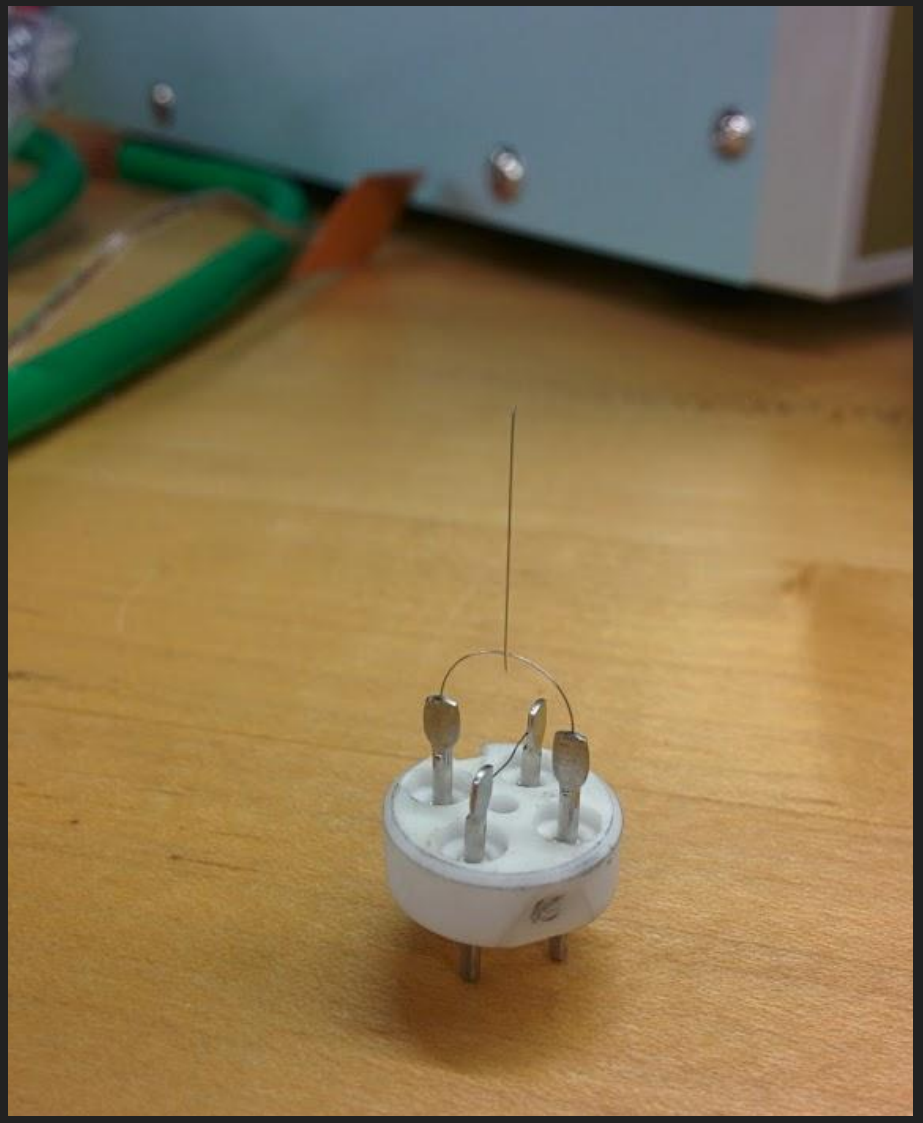
Recrystallizing tungsten wire

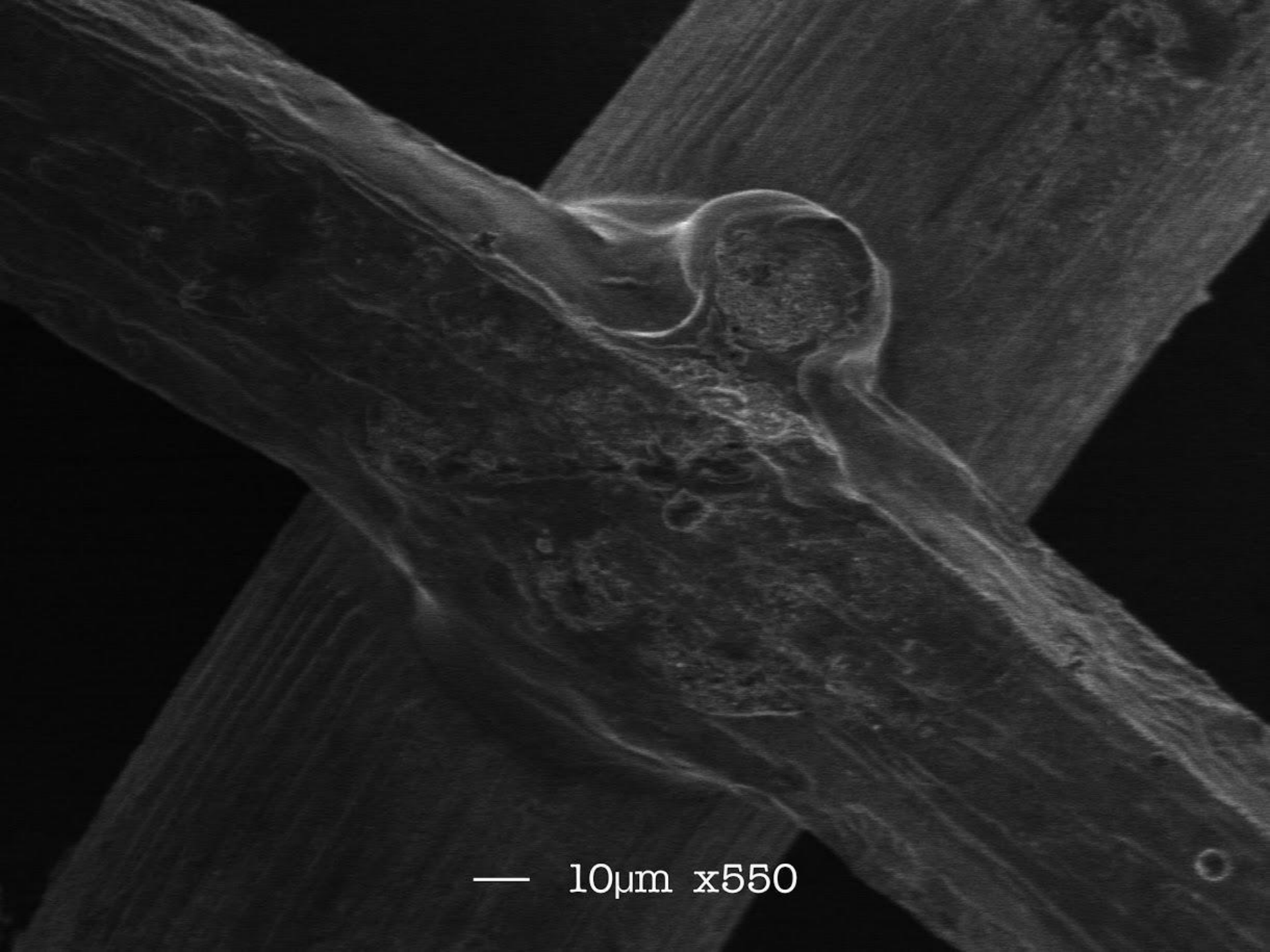


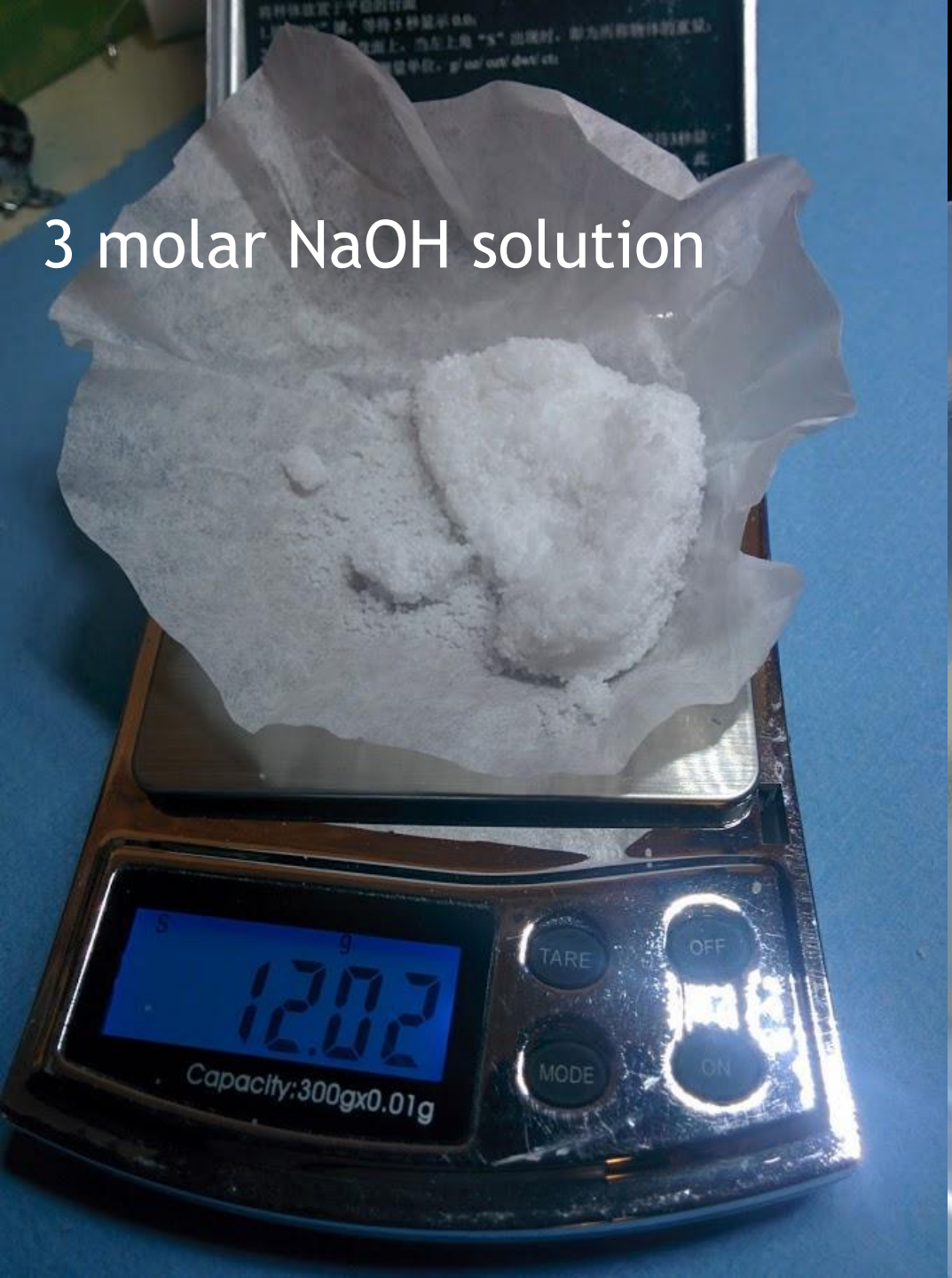
http://www.surfacesciencenetwork.com/wiki/index.php?title=Tungsten_wire_recrystallization

Welded!






10µm x550



3 molar NaOH solution

Tip will preferentially etch at the meniscus

The drop-off method

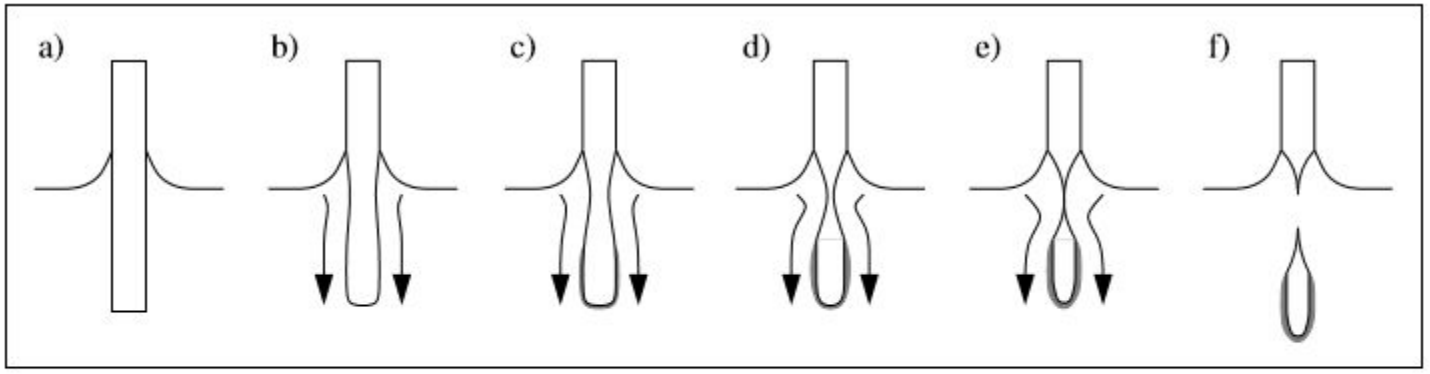
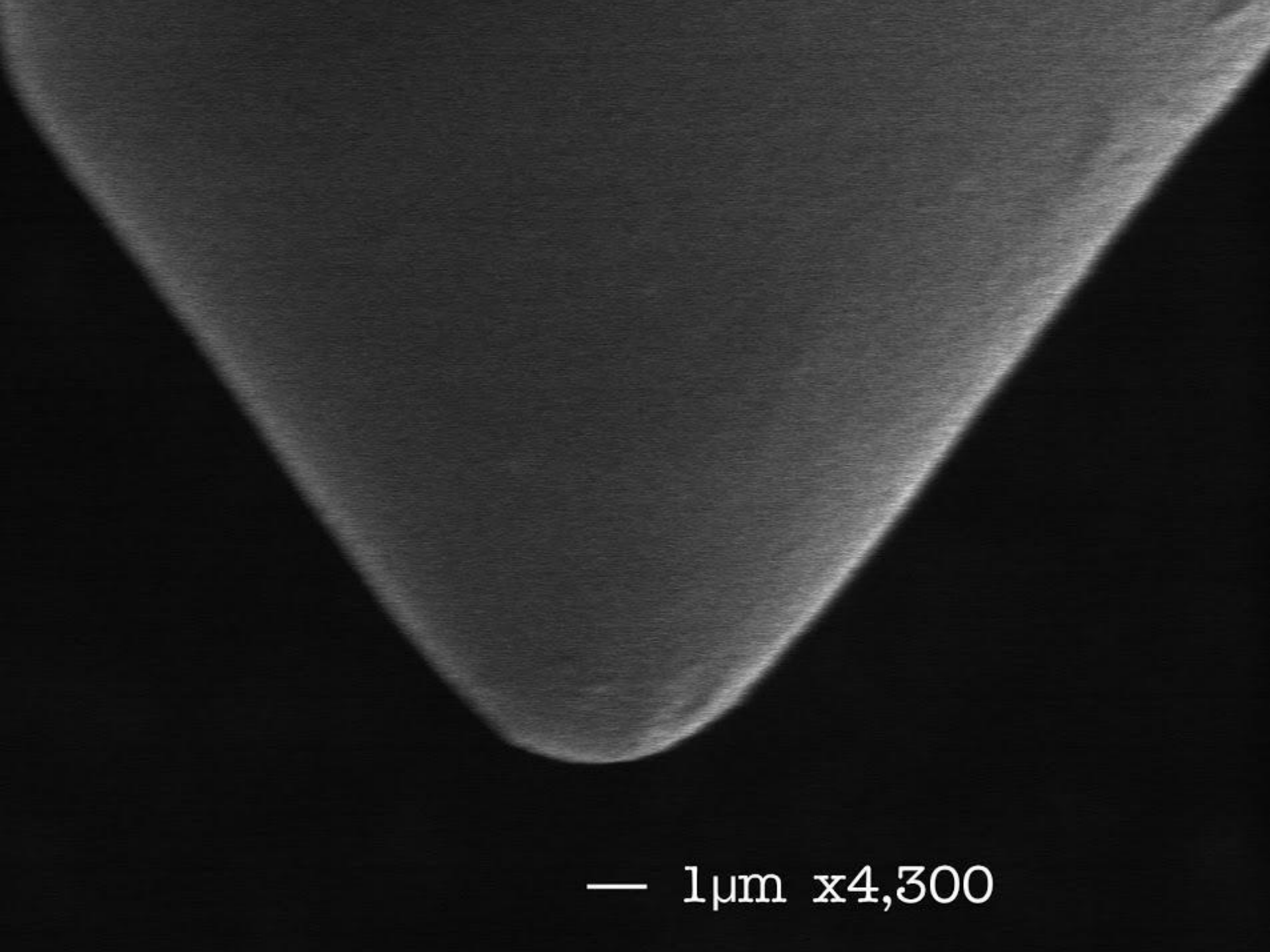


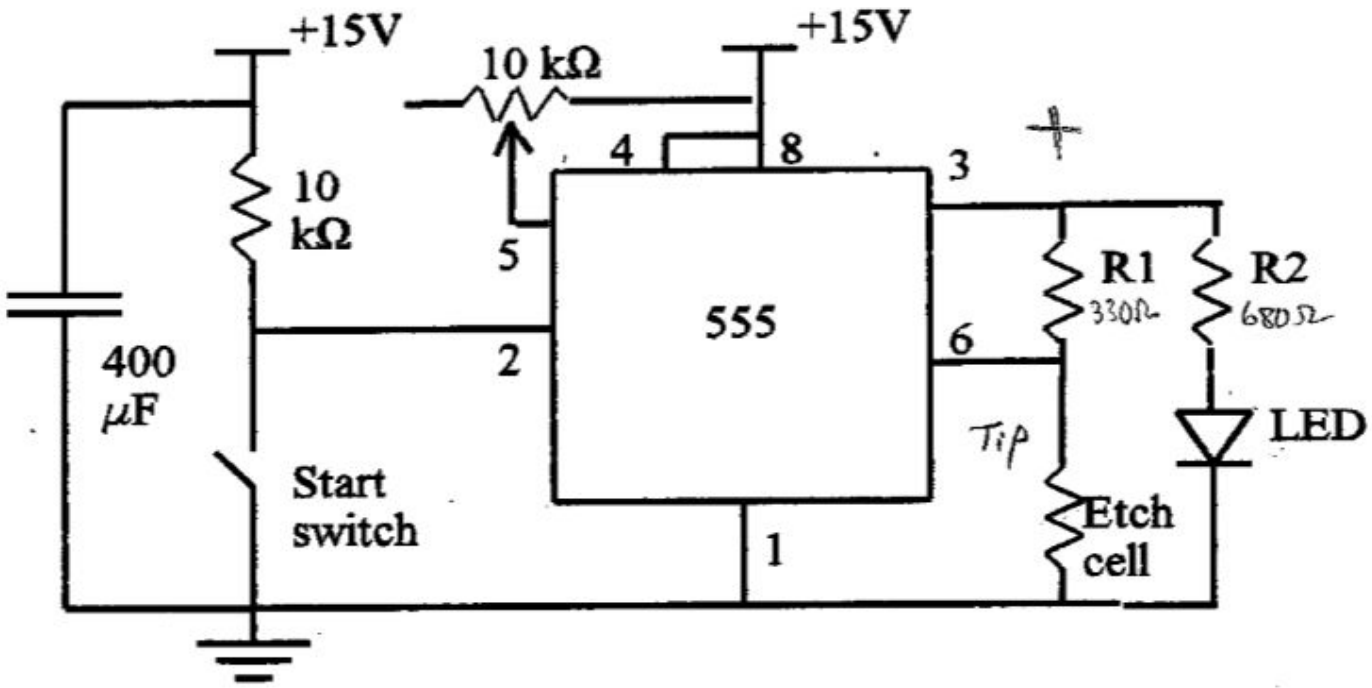
Figure 2.3: Illustration of the drop-off method. a) shows the formation of the meniscus. b) to e) illustrate the flow of WO_4^{2-} towards the lower end of the wire, the formation of a dense layer of WO_4^{2-} around the bottom of the wire and the necking phenomenon in the meniscus. In f), the lower part breaks off: the drop-off has occurred.

Anne-Sophie Lucier, thesis for McGill University, February 2004

http://www.physics.mcgill.ca/~peter/theses/lucier.pdf


— 1µm x4,300

Switch off the current as quickly as possible



Michael C. Robinson, thesis for Queen's University, July 2000

https://doi.org/10.1142/S0218625X99000810

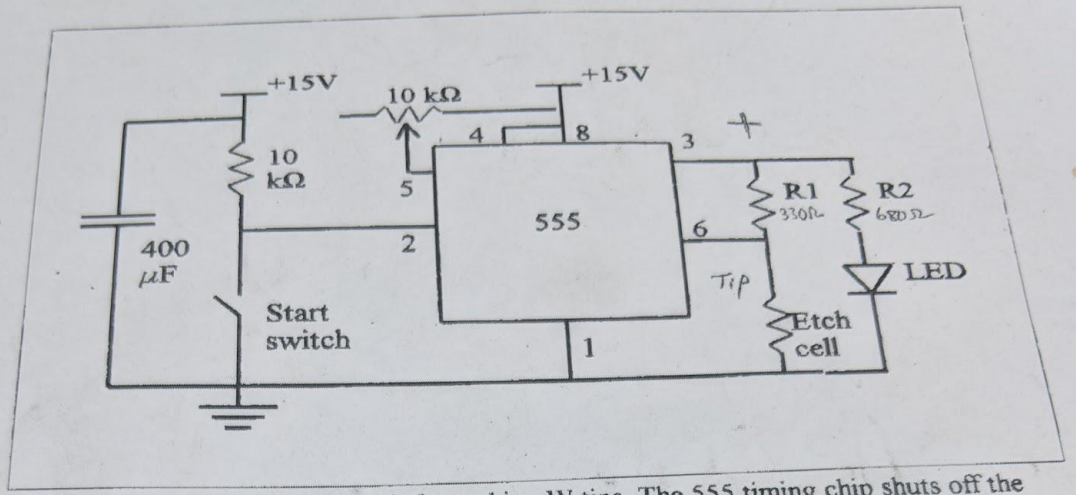


Figure 2.2.3. The etching circuit for making W tips. The 555 timing chip shuts off the current to the etch cell within 200 ns.

current flowing through the circuit decli… …o higher resis…

…d change is detected

…or greatest possible speed

…tage cut-off time: fast…

…onic cut-…

…round experiment…

cut-off results in sharper tips [Ibe *et al.*, 1990]. Becau…

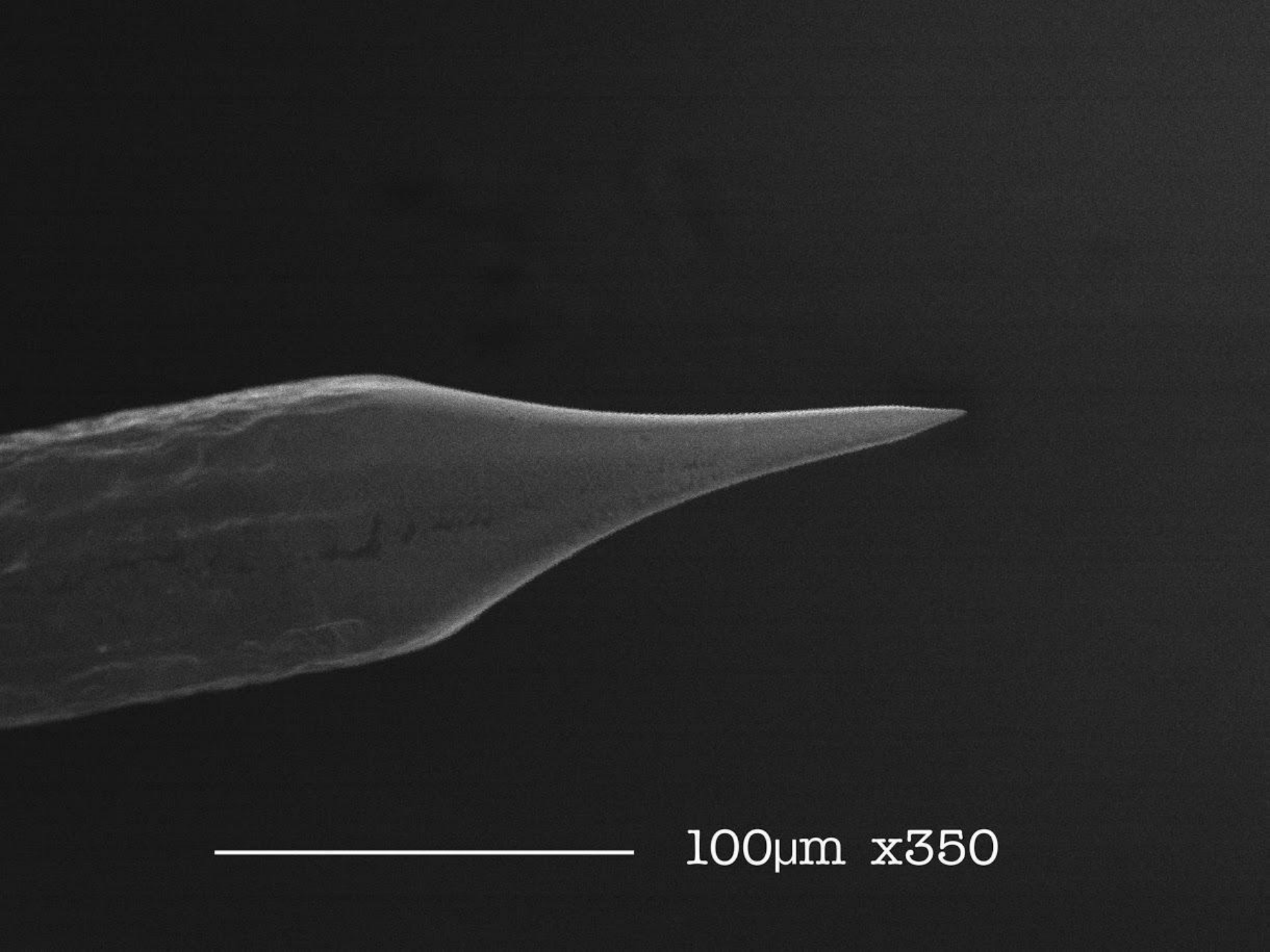
circuit has been built.

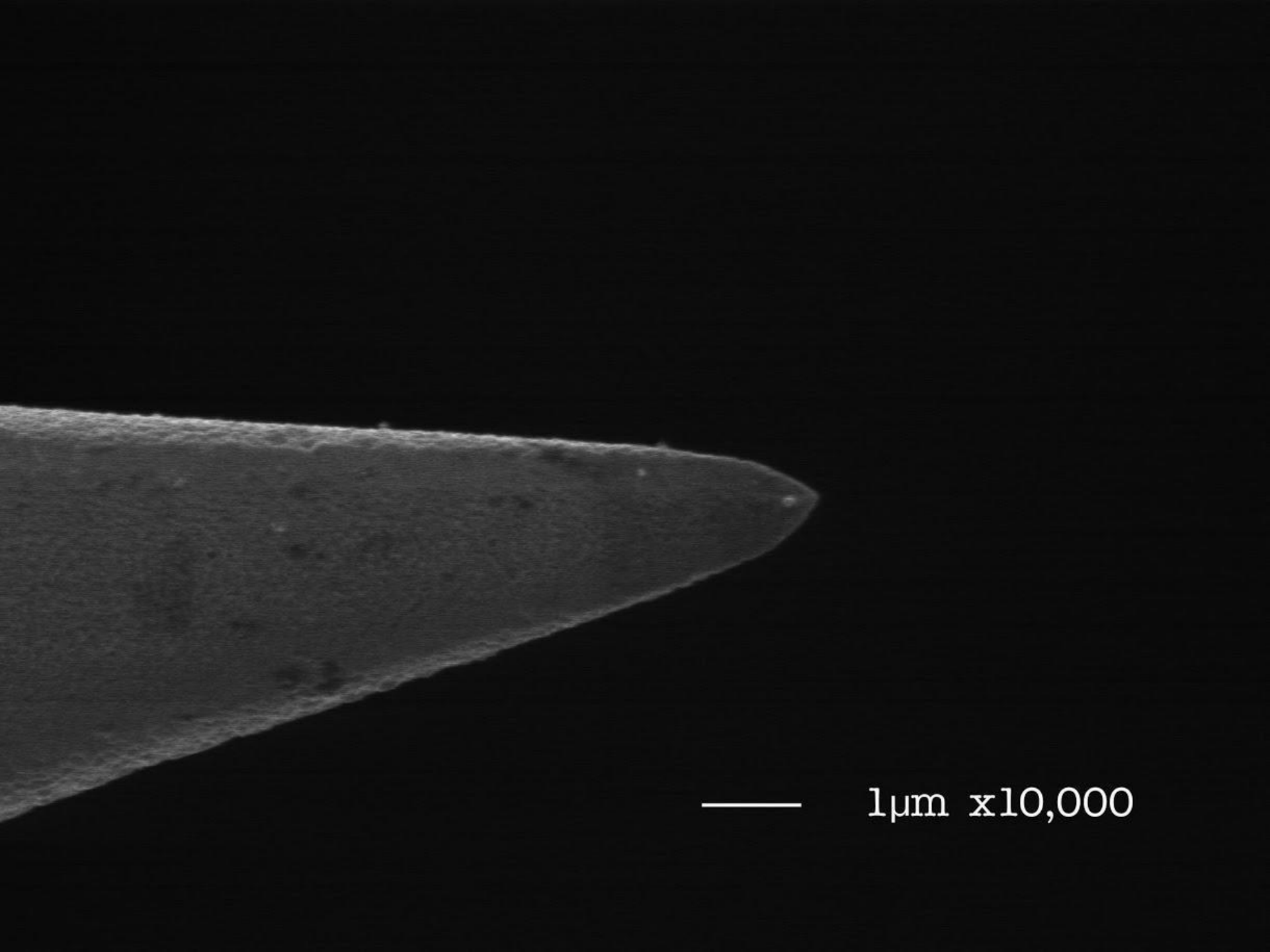
Fig. 2.2.3 is a schematic of the electro… …ut-off …rcuit, based on a standa…

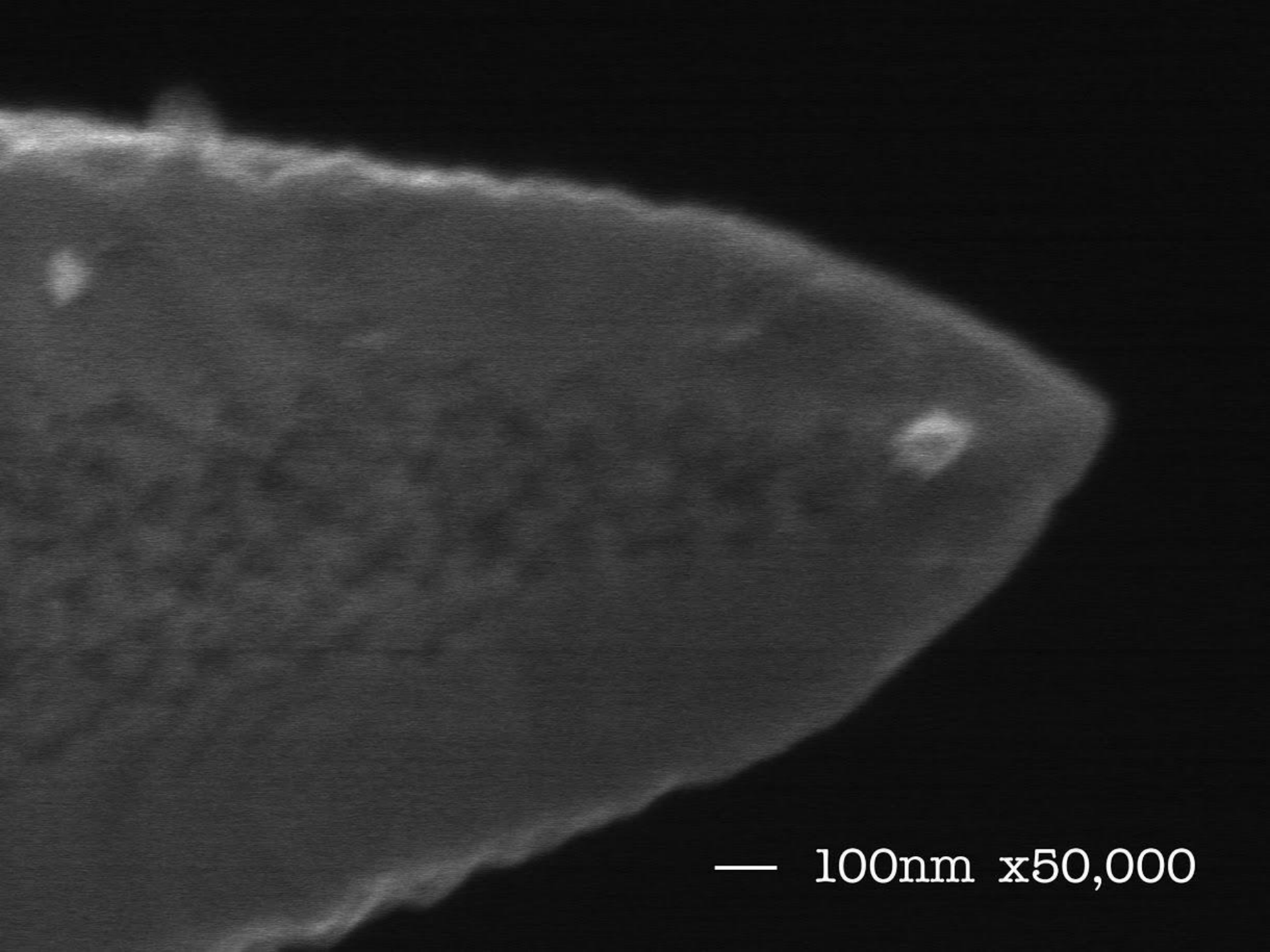
timing chip, designed and built … …ft at Trent …niversity. The cut-off time was

measured at about 200 … …ole for generating tips sharp enough … atomic resolution

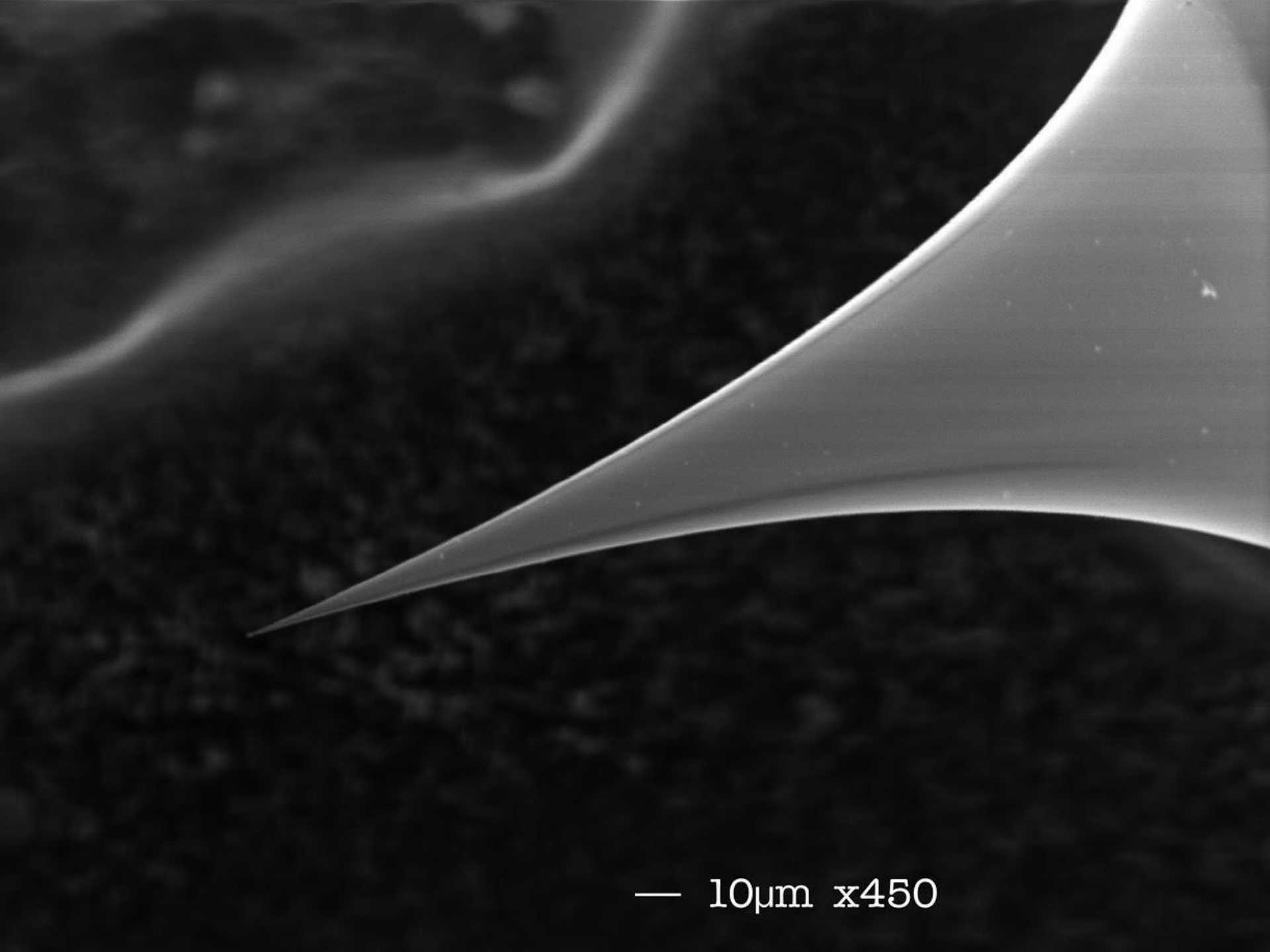
on metals. The … …inexpensive … simple to build. Pin … …ies the dc etch

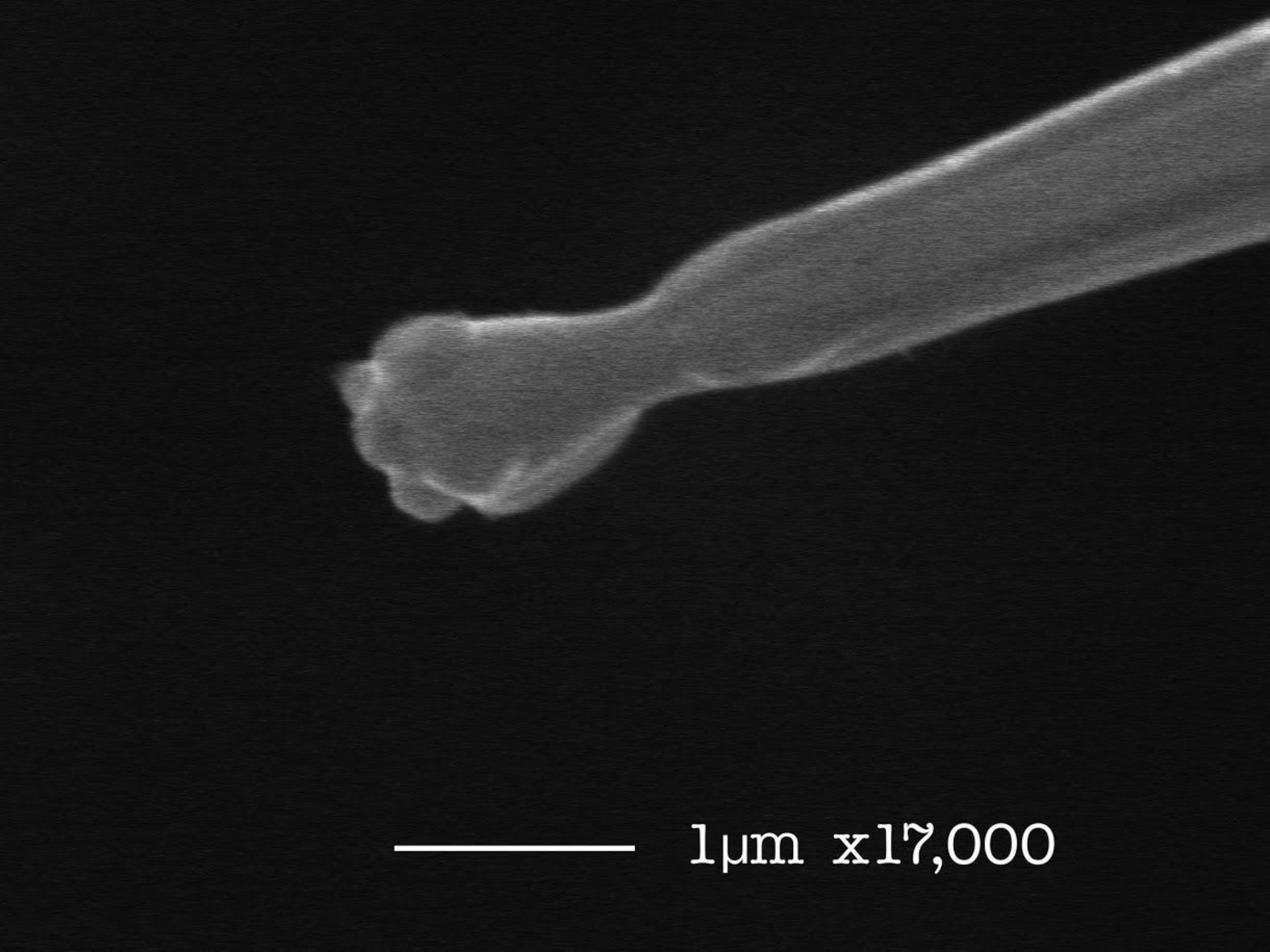

100µm x350


1µm x10,000

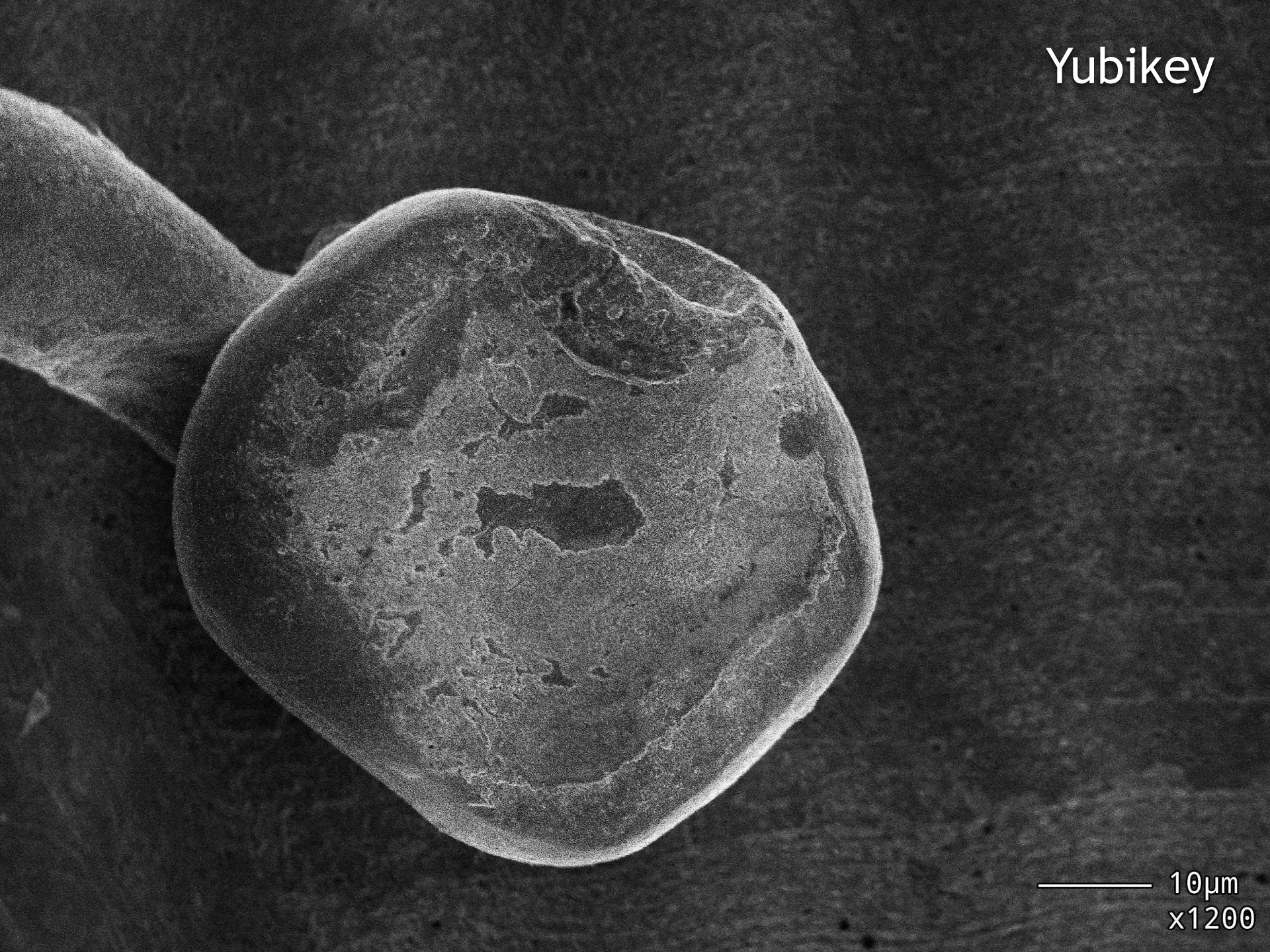

100nm x50,000

48 hours later...

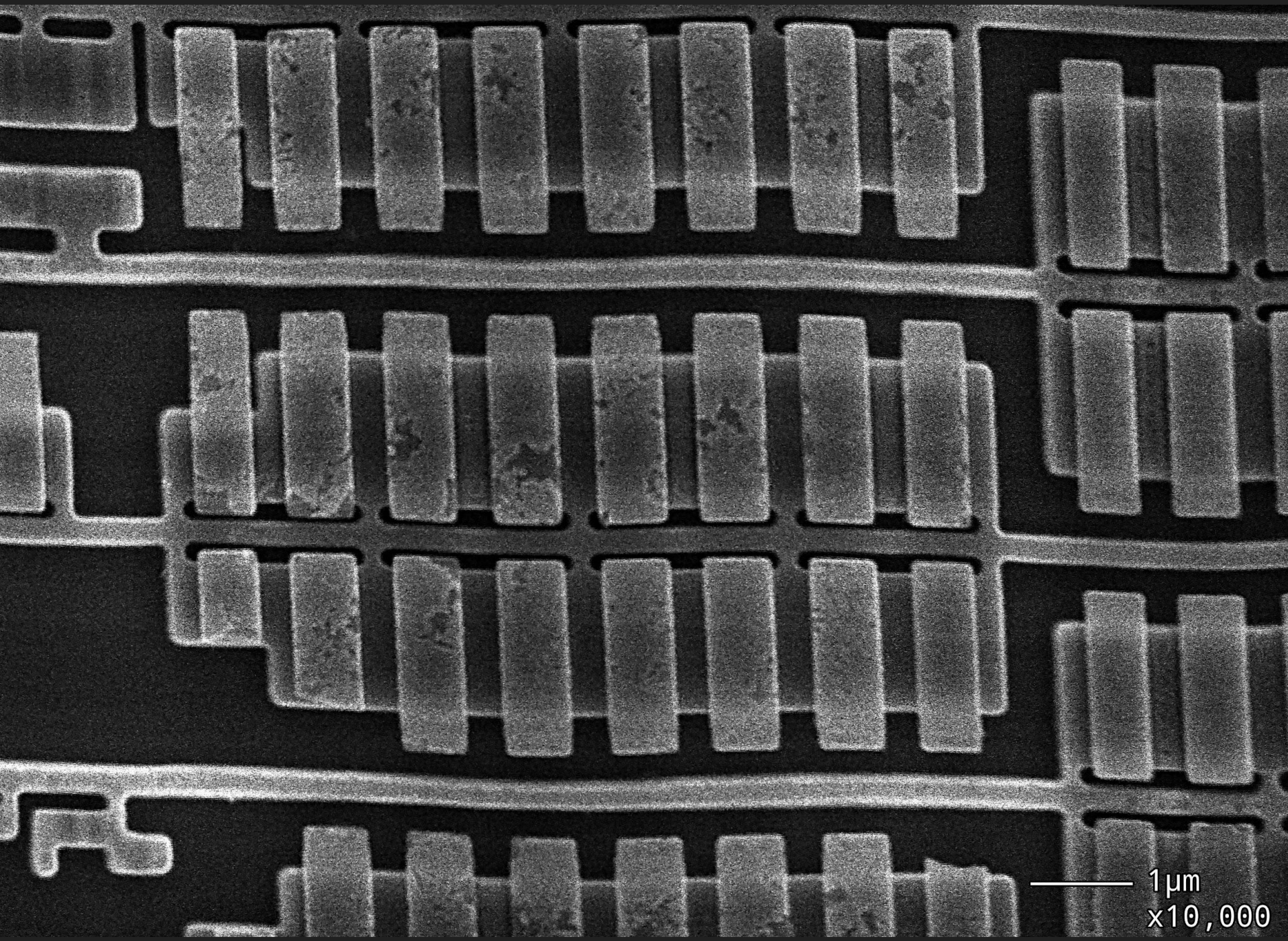

— 10µm x450

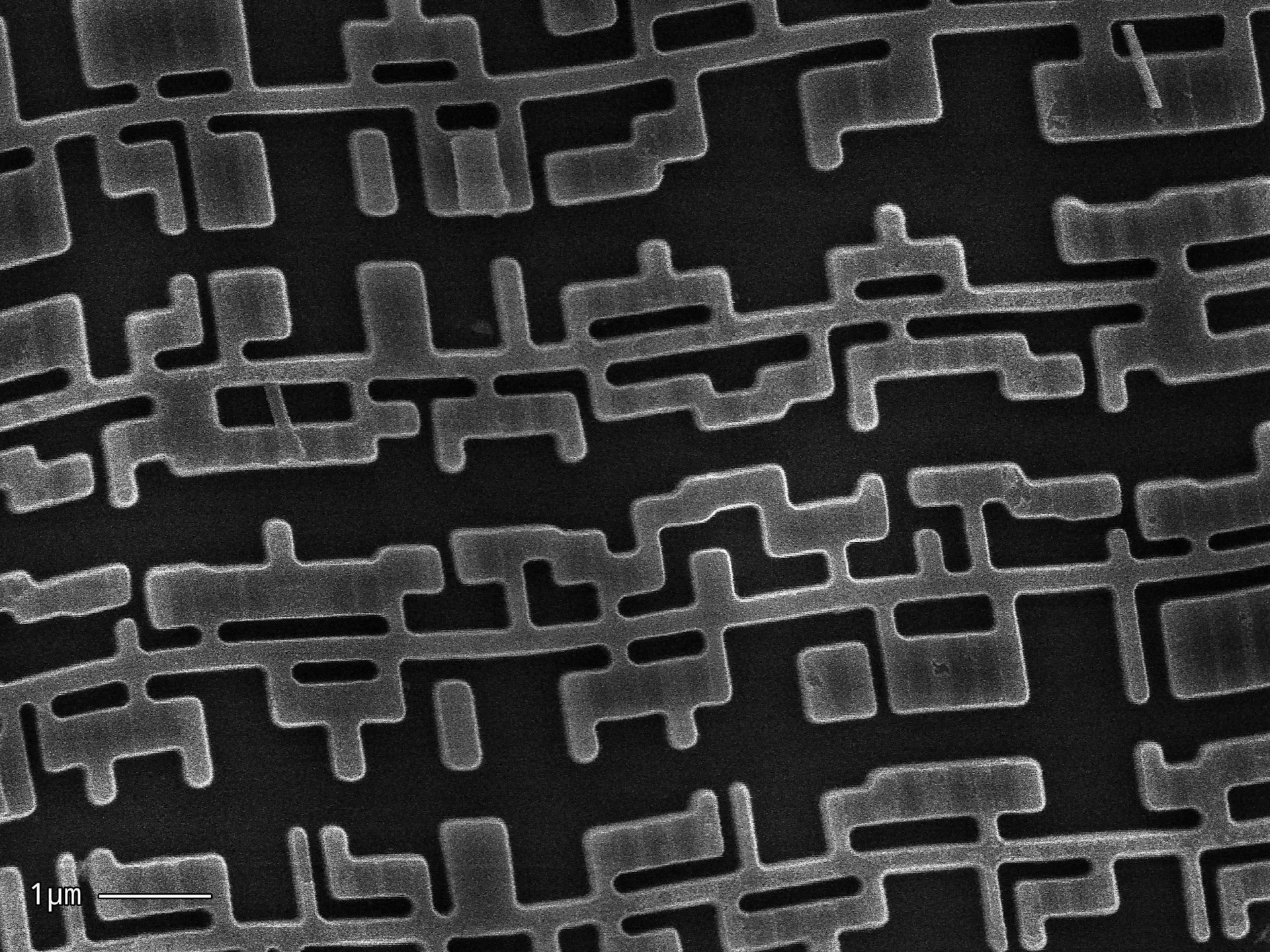

1µm x17,000


Gallery of tiny things

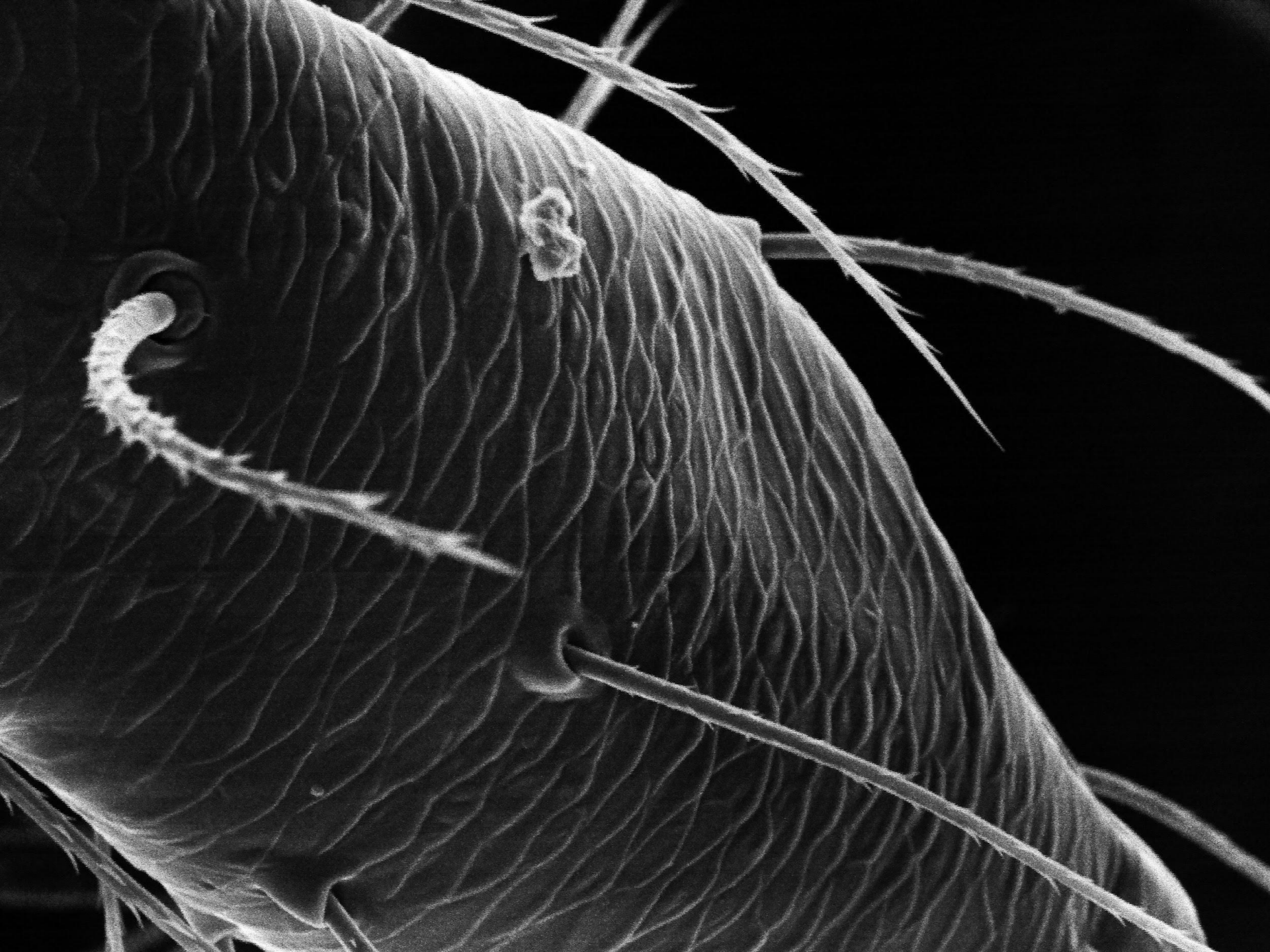

Yubikey
10µm
x1200


10µm

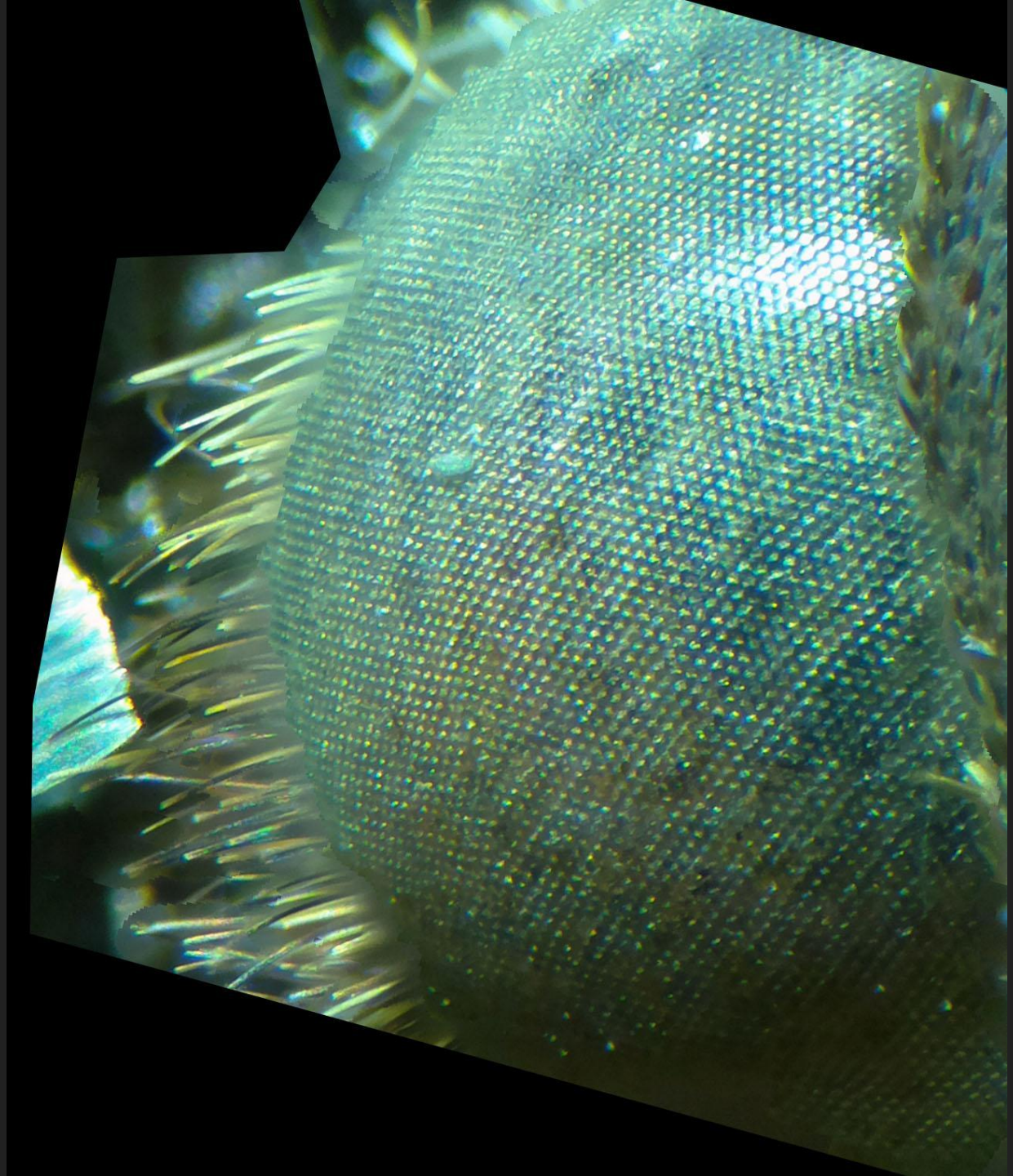

1µm
x10,000

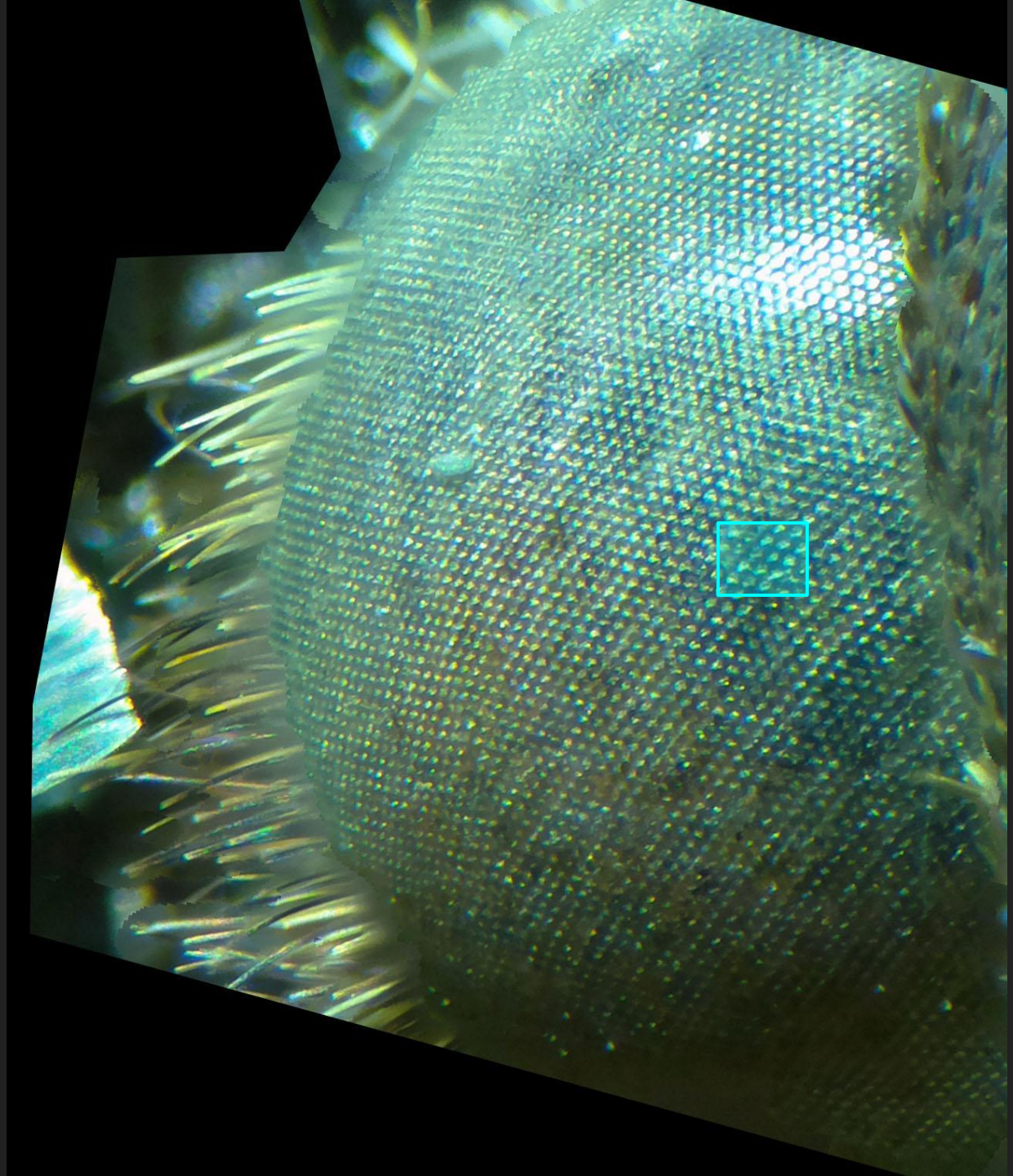

1 µm

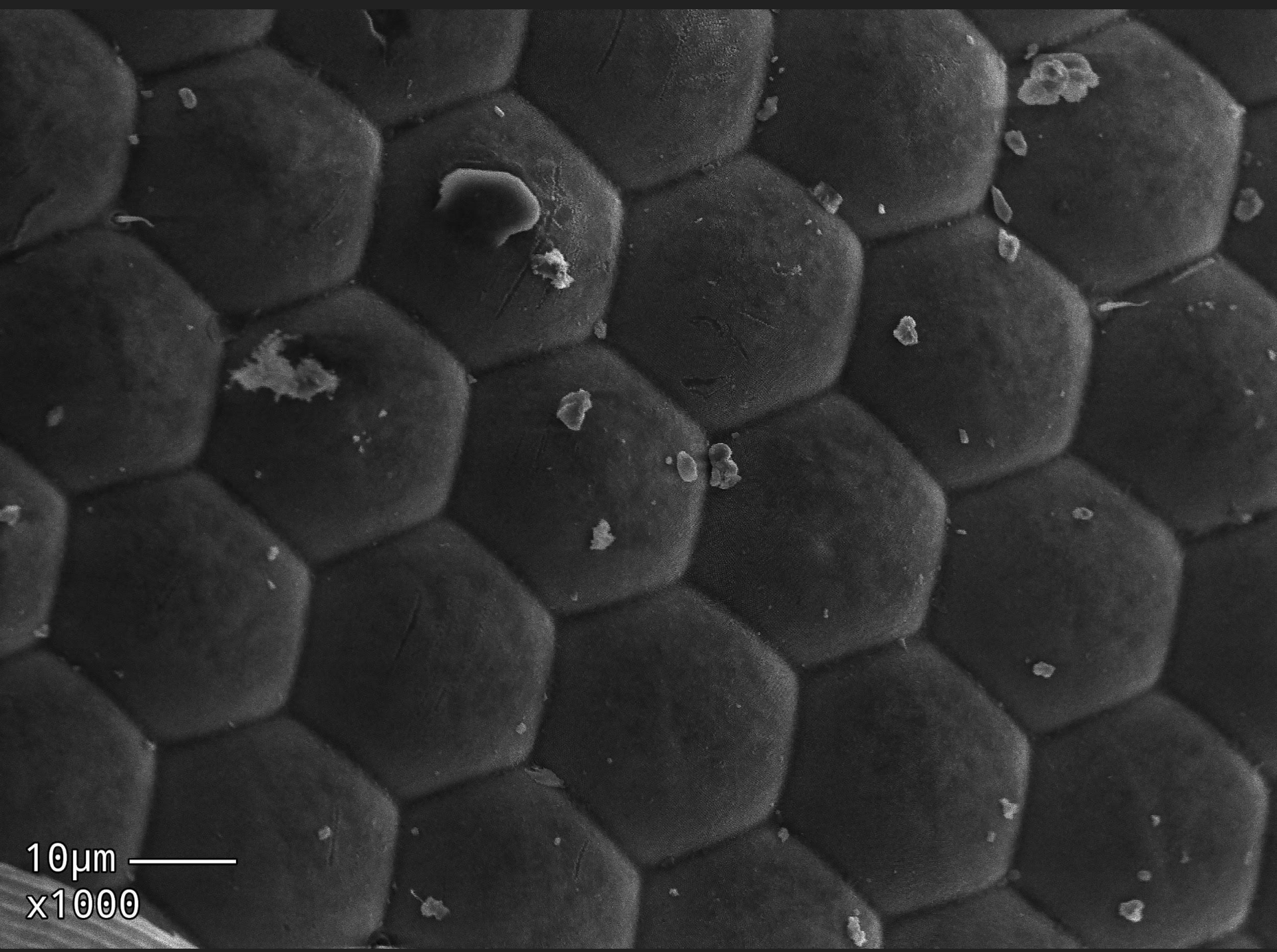
INSECT ALERT!

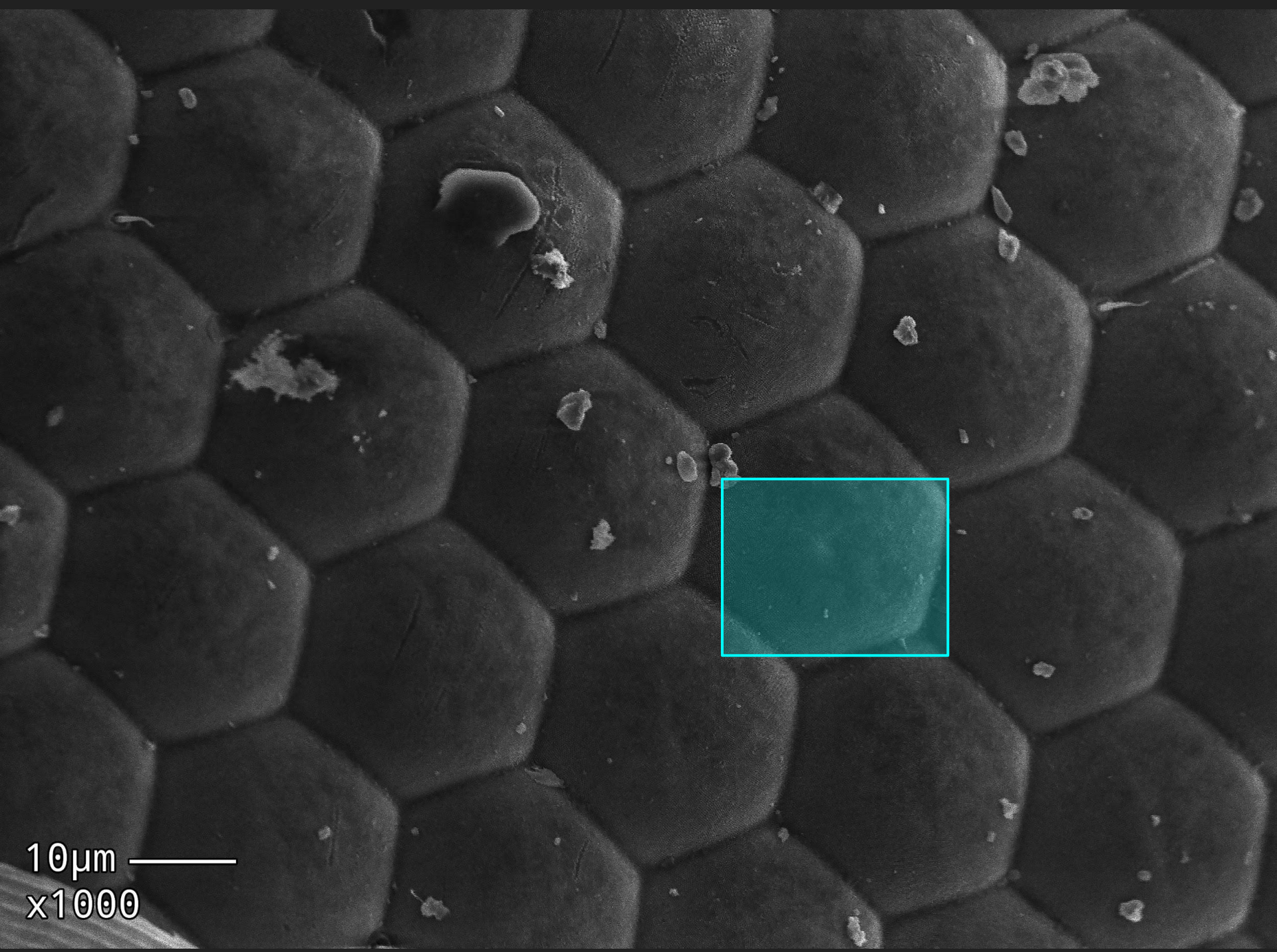


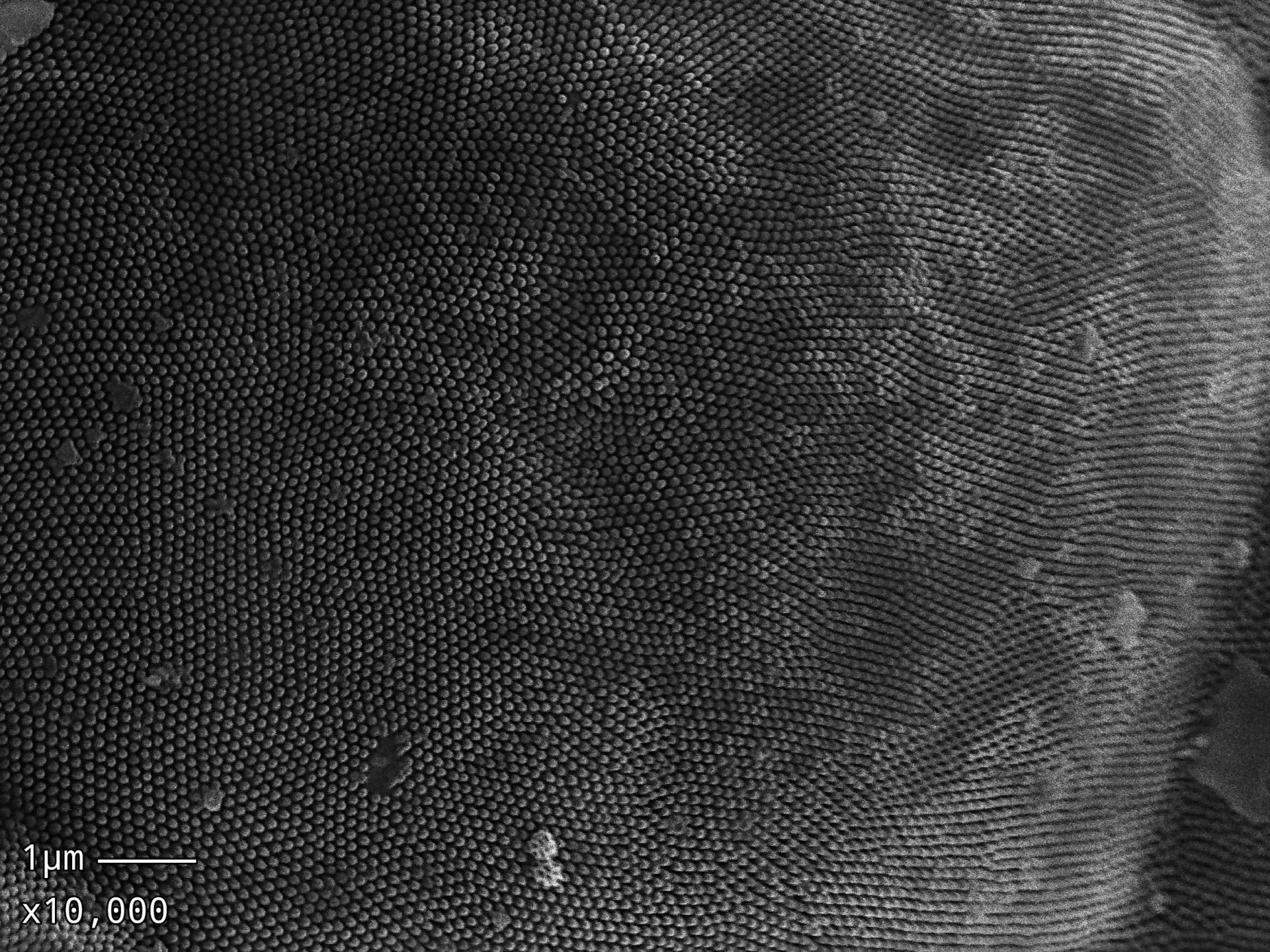

mosquito x650
10µm

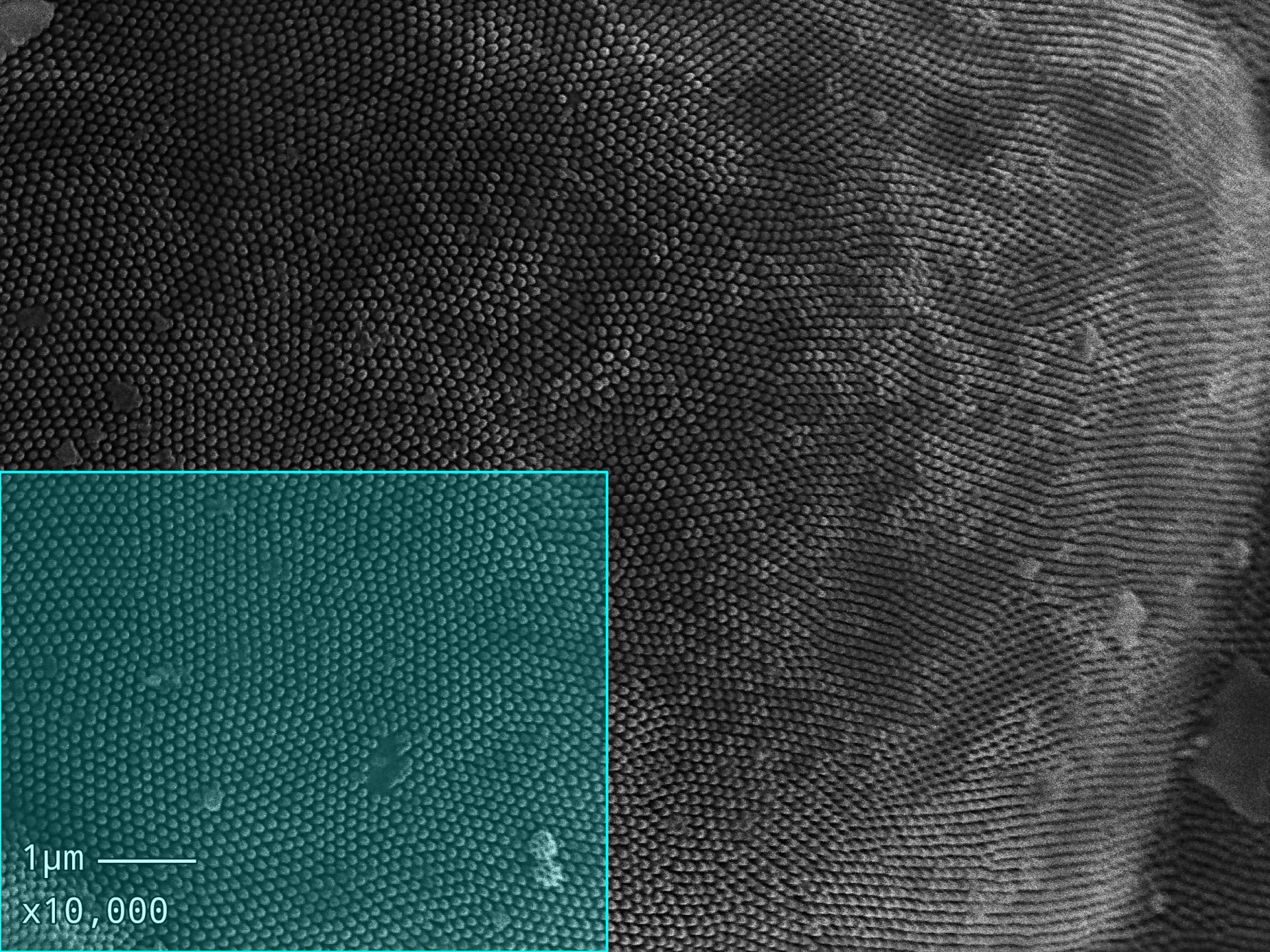


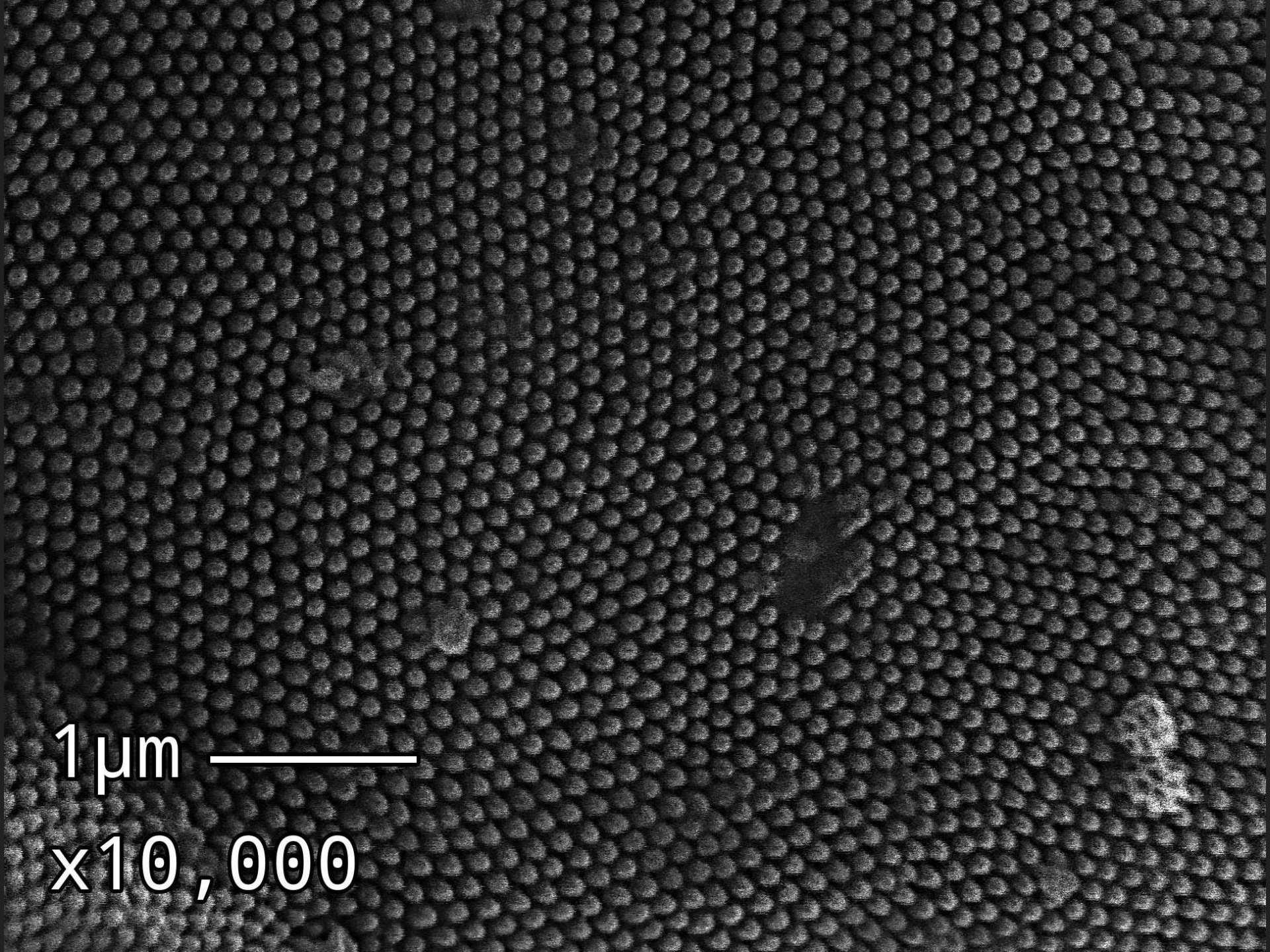


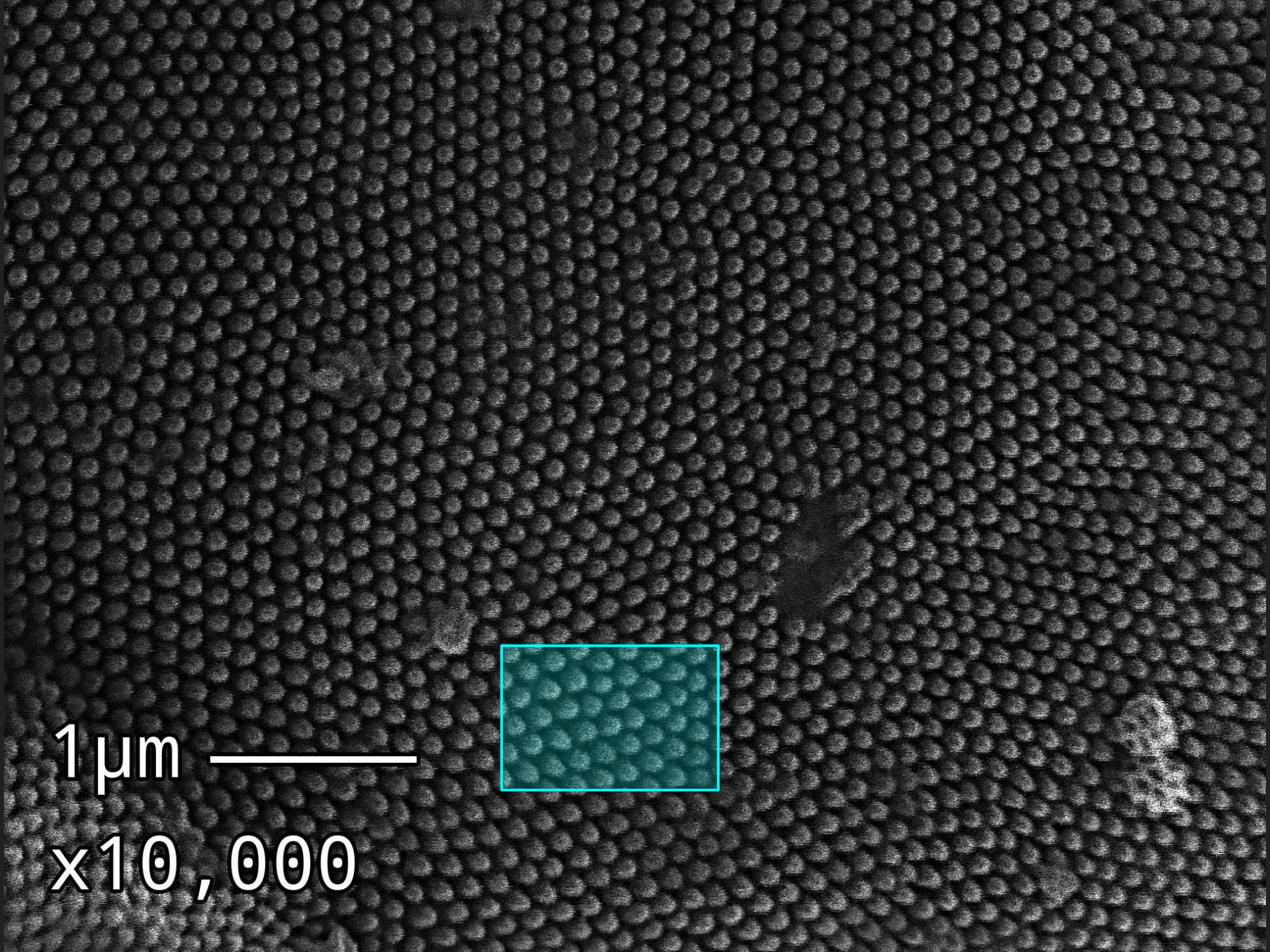

10µm
x1000

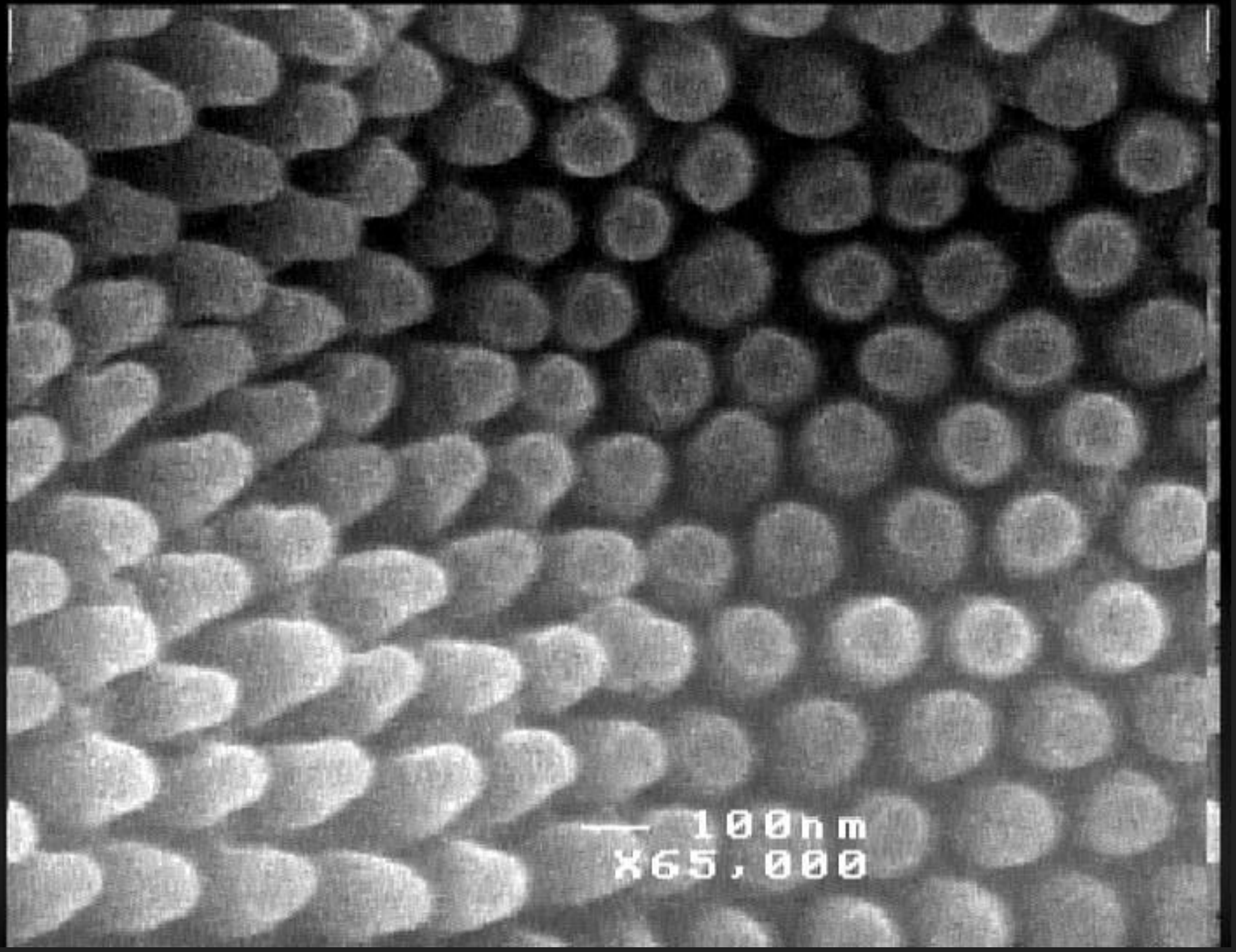

10µm
x1000

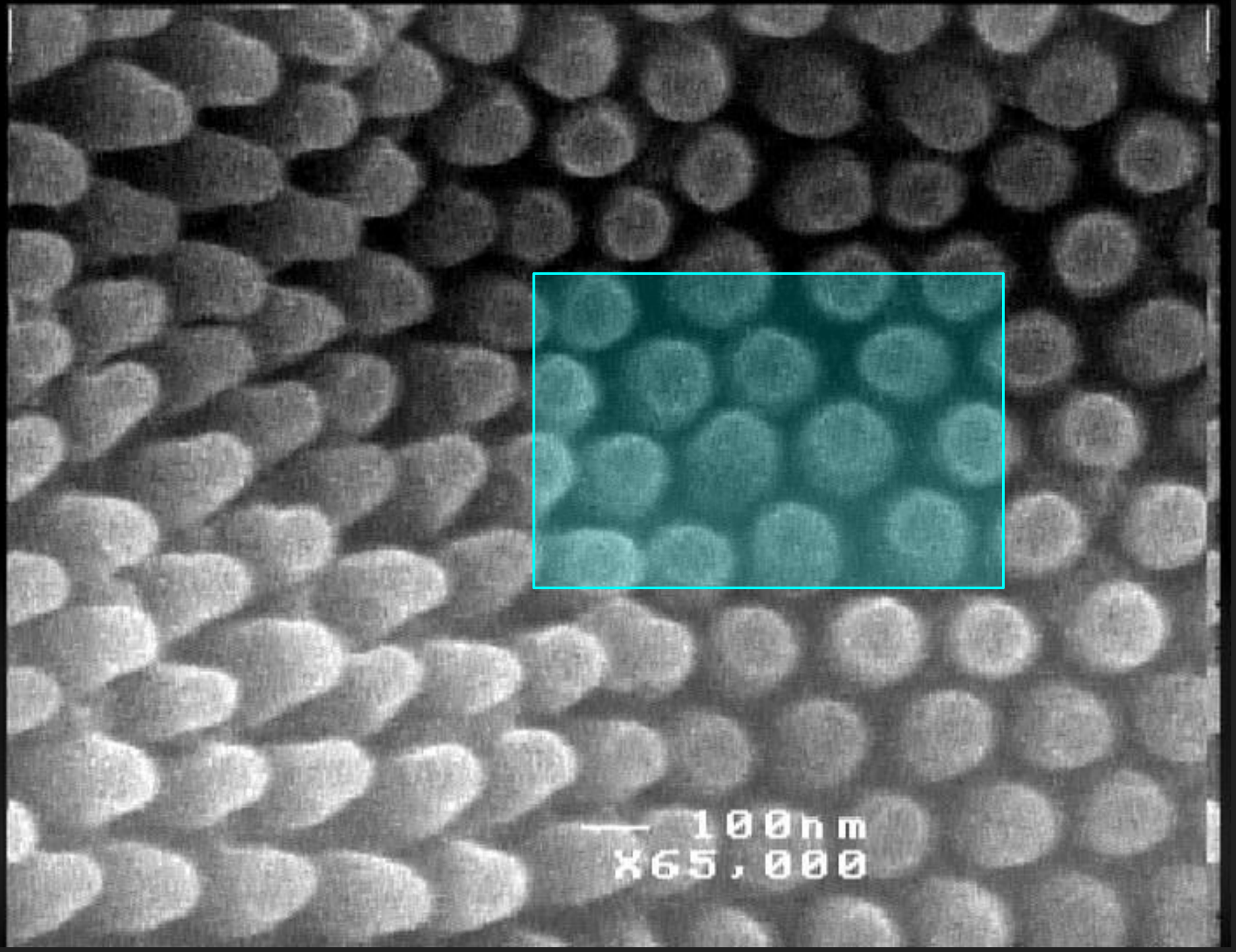

1µm
x10,000

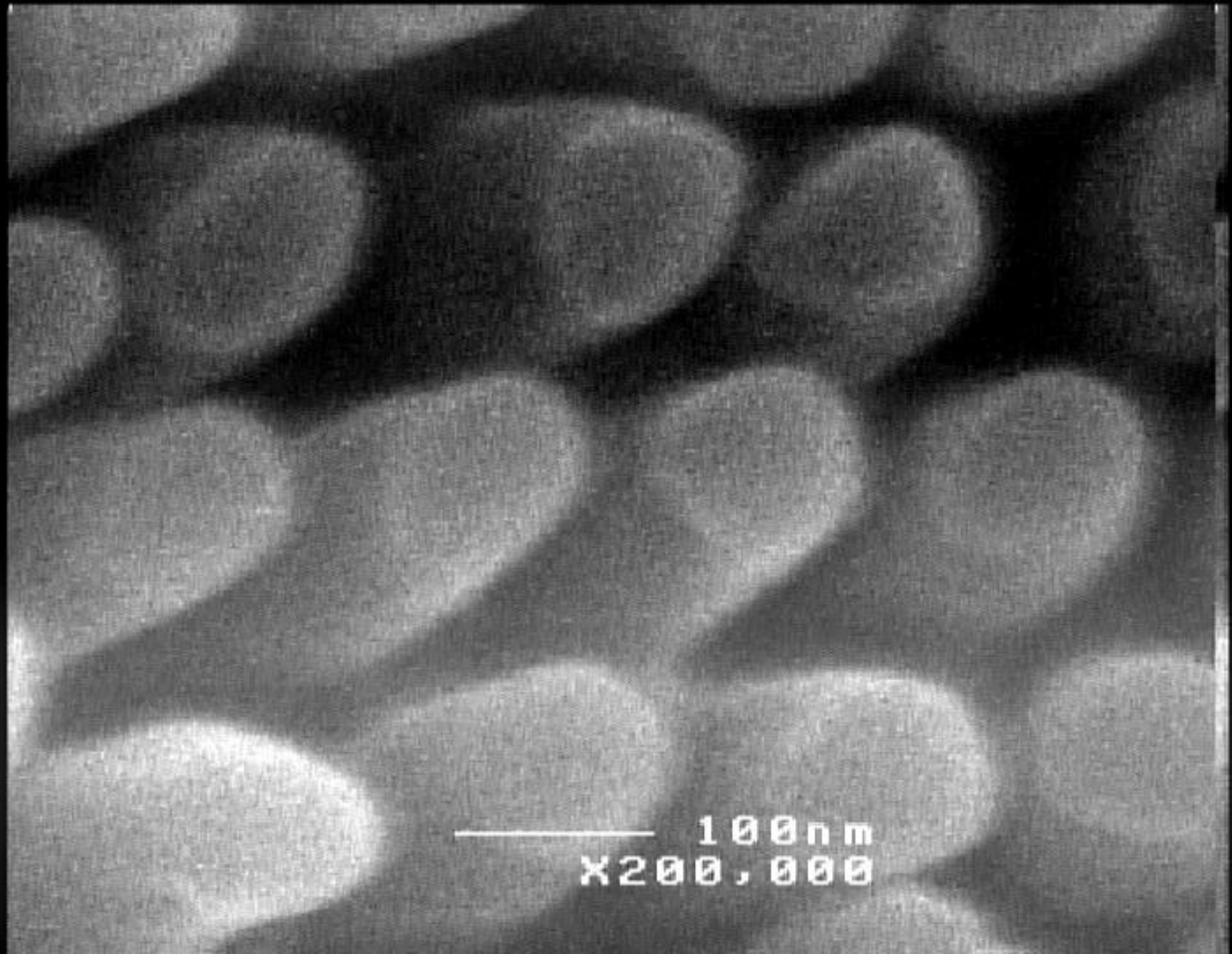

1µm
x10,000

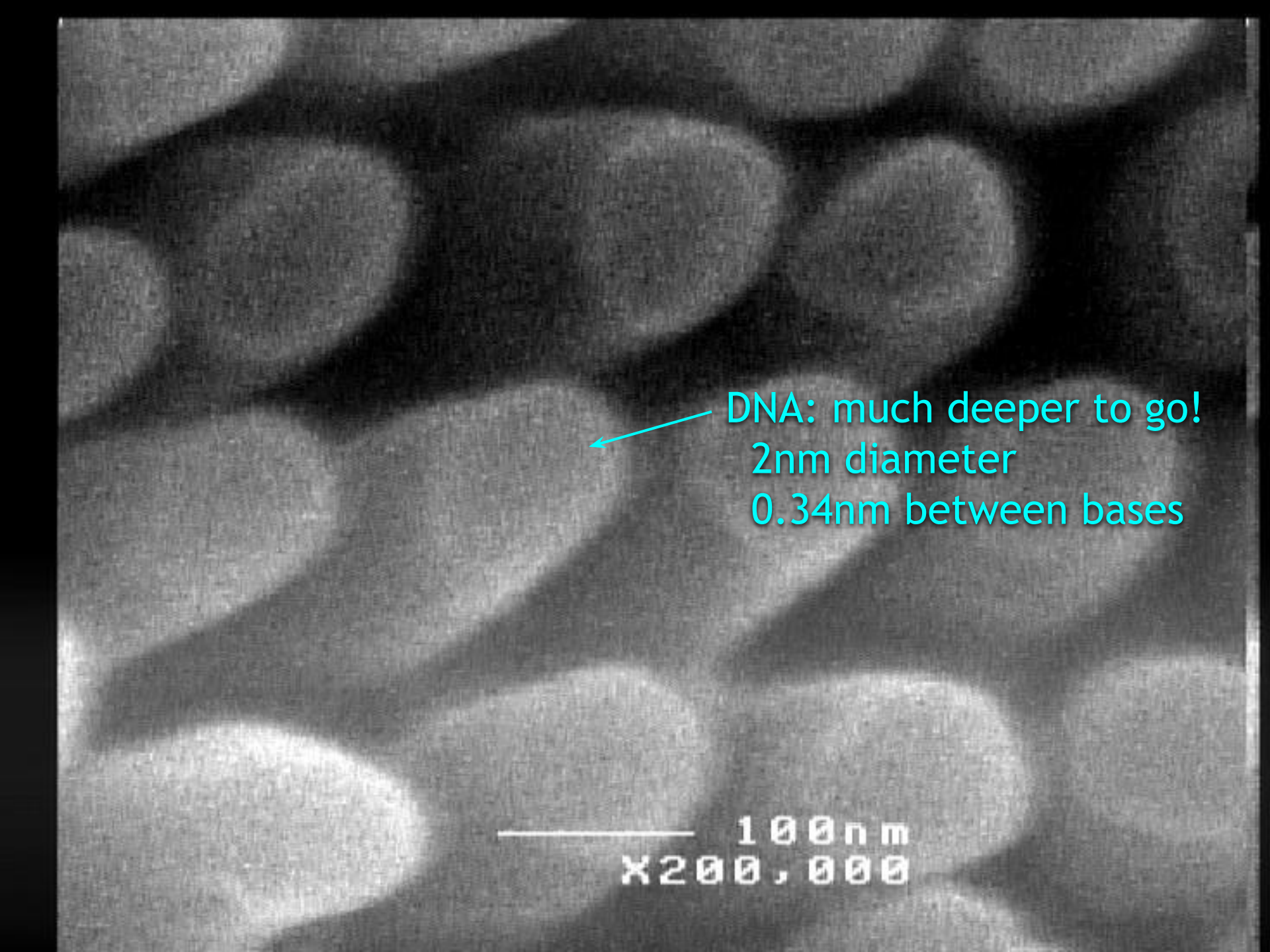

1µm
x10,000

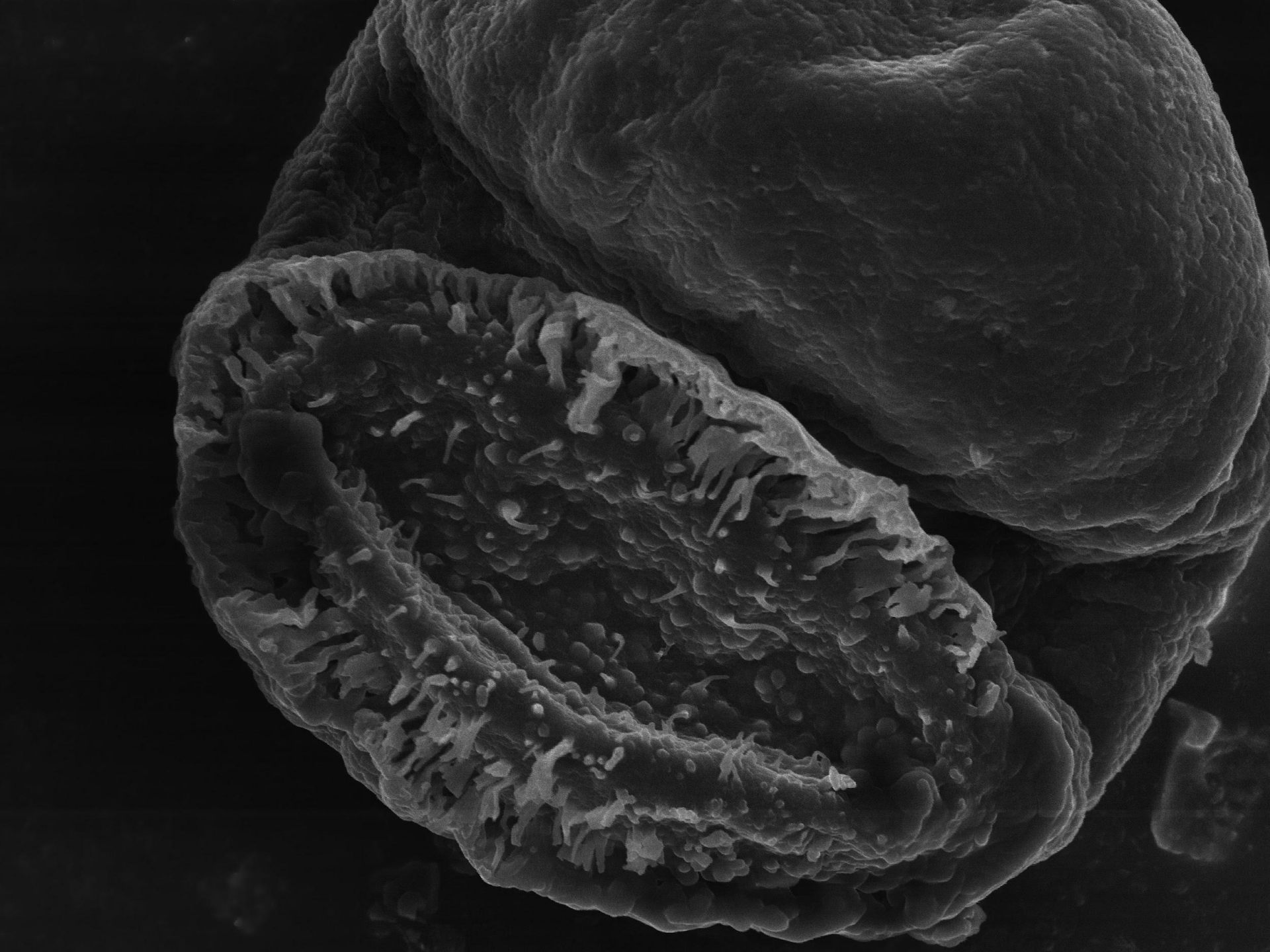

1µm
x10,000

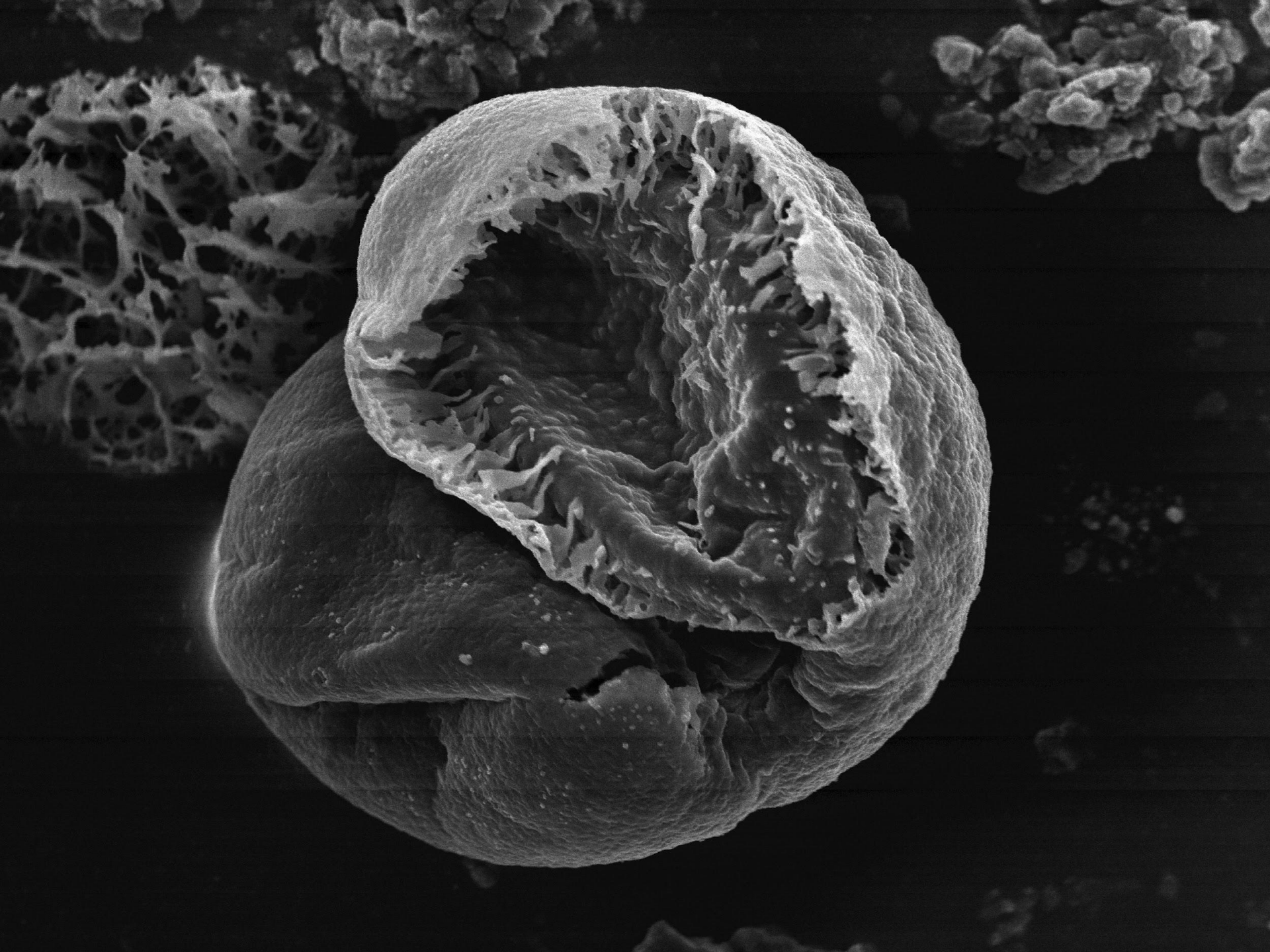

100nm
X65,000

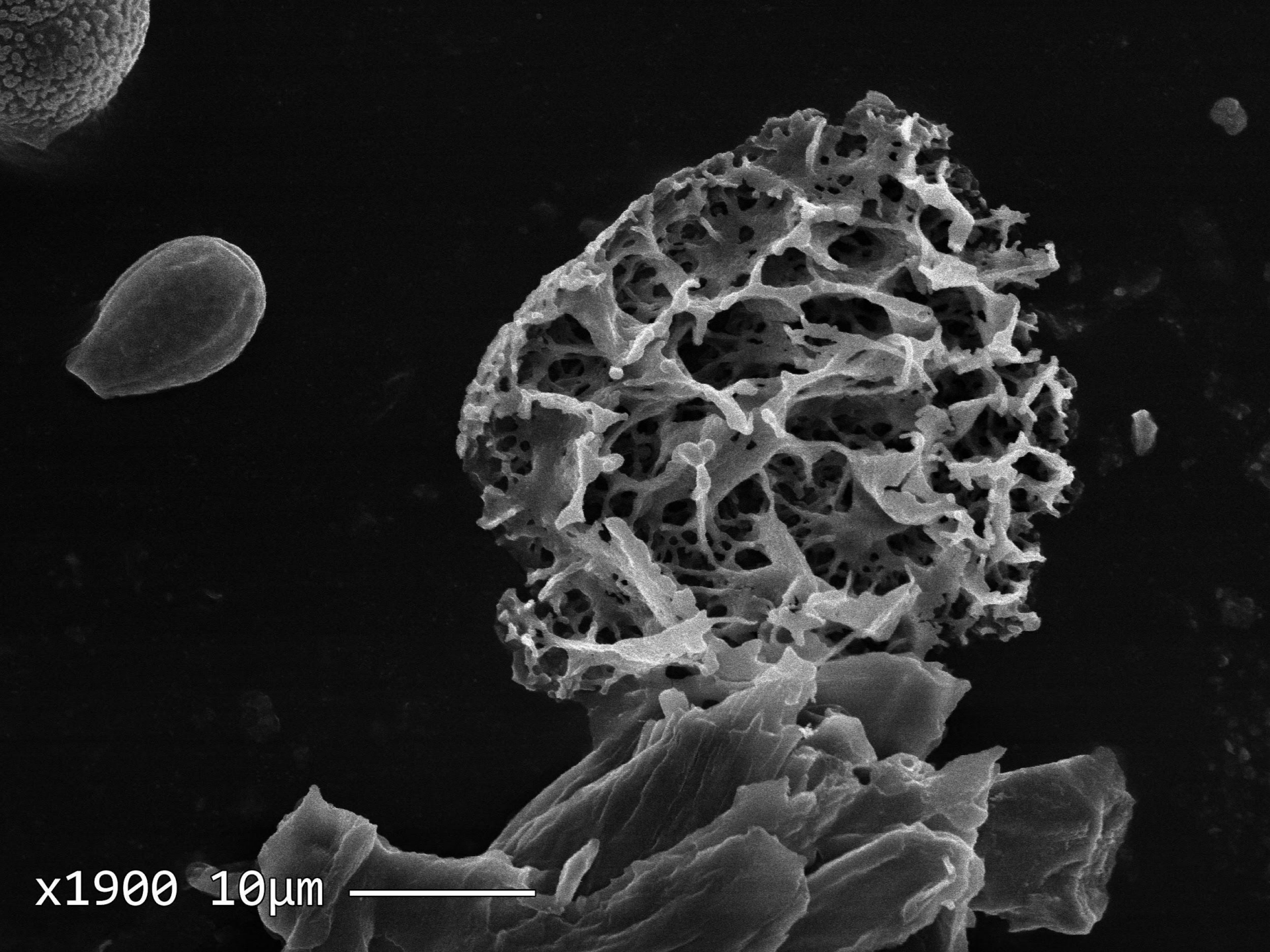

100nm
X65,000

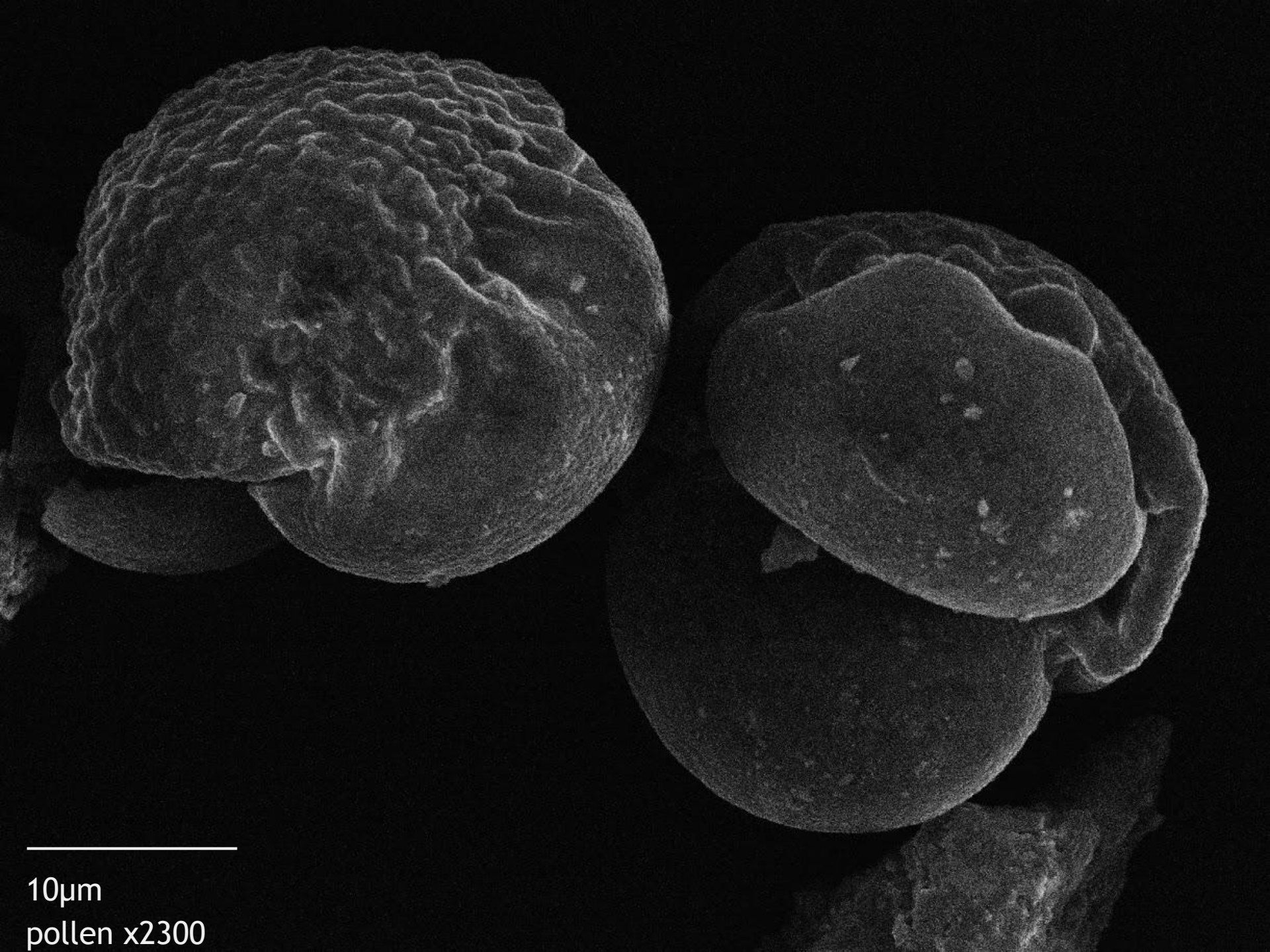

100nm
X200,000

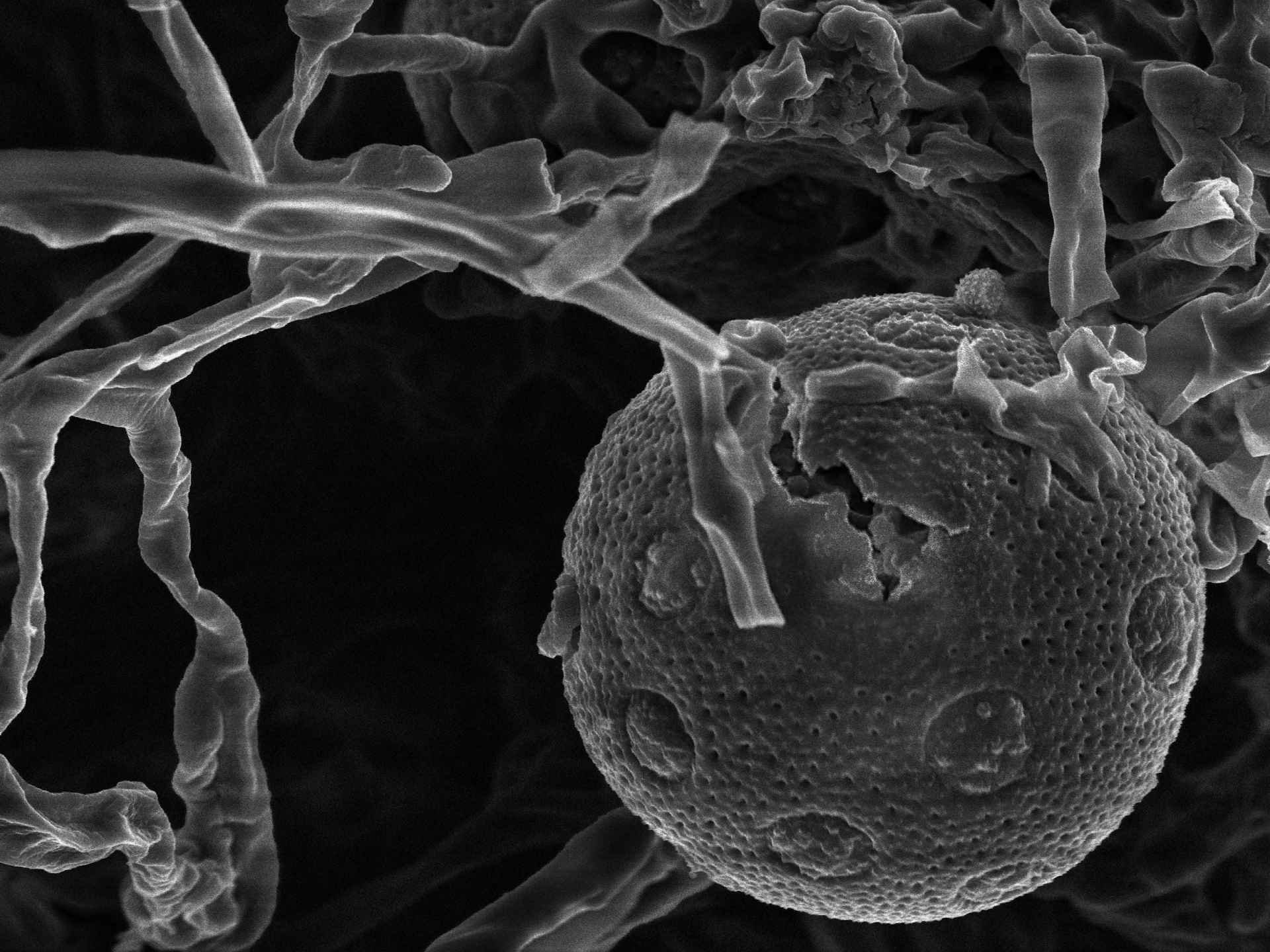

DNA: much deeper to go!
2nm diameter
0.34nm between bases
100nm
X200,000

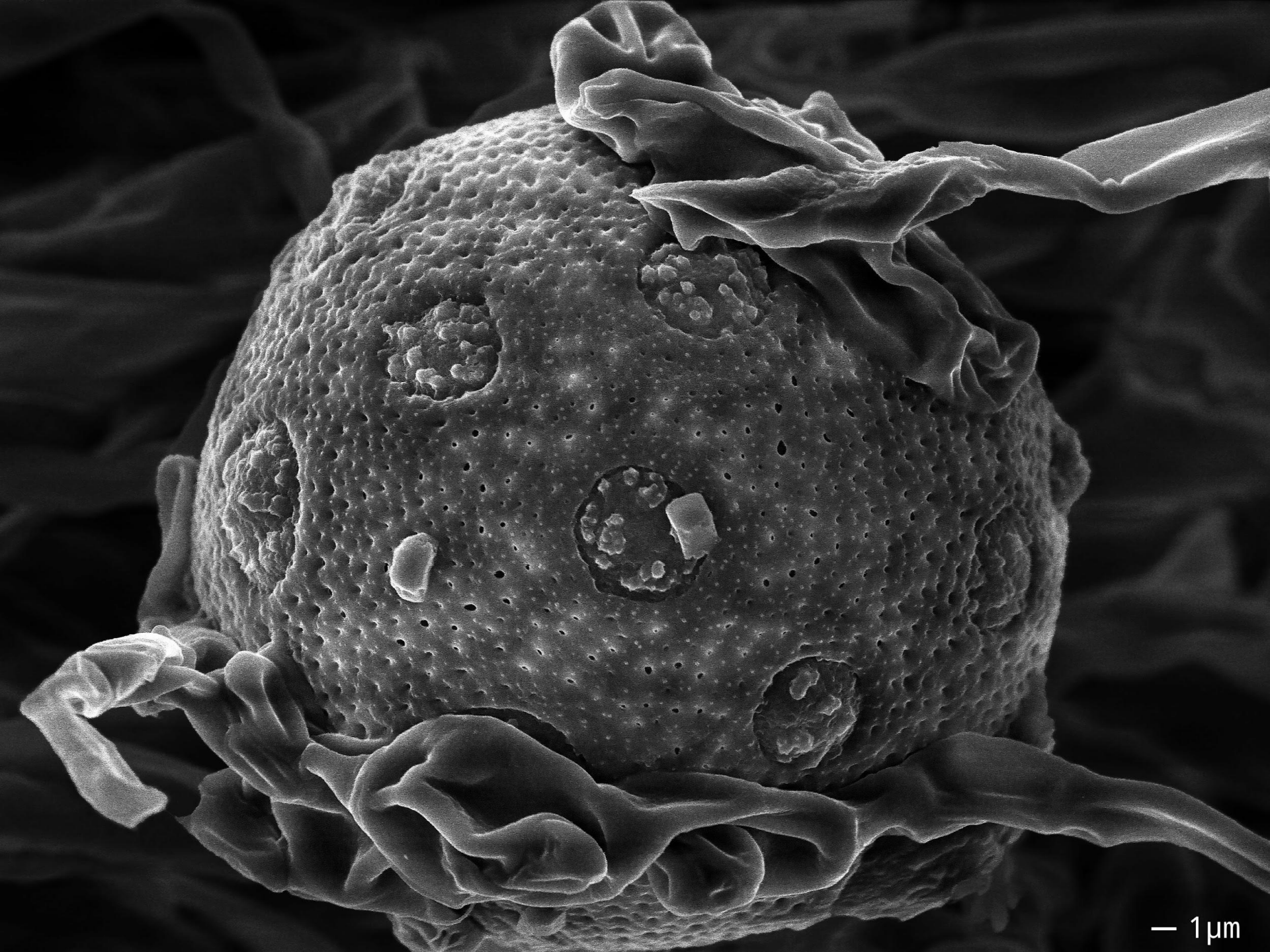





x1900 10µm


10µm
pollen x2300




— 1 µm


Rob Flickenger
hackerfriendly.com
— 1 µm