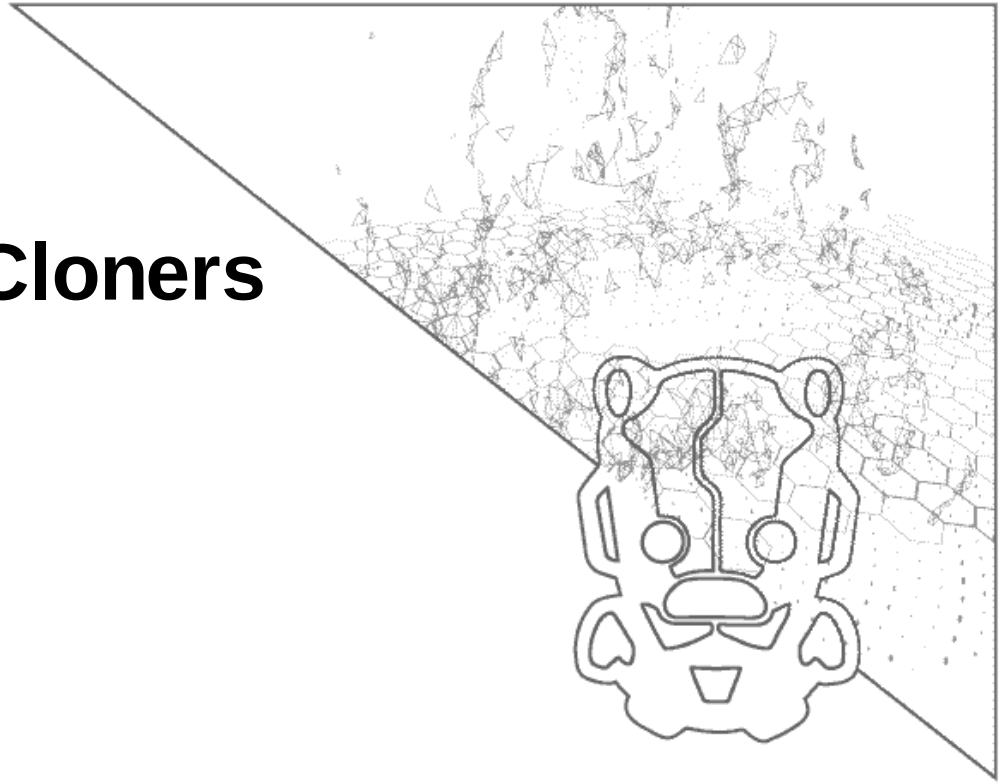
Secure Elements vs Cloners

A Case Study

Andrew D. Zonenberg, Ph.D.
Principal Security Consultant



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Researcher and Briefer

Andrew D. Zonenberg, Ph.D.

Principal Security Consultant

Bio: Andrew specializes in security at the hardware-software interface. His research interests range from probing of multi-gigabit serial interfaces to gate-level IC reverse engineering. In 2014, he taught the world's first university course on semiconductor reverse engineering.

He has presented at a wide range of industry and academic conferences, workshops, and events across North America and Europe.

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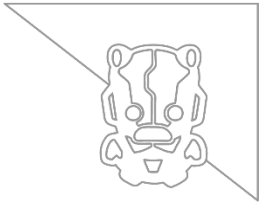
The Big Picture



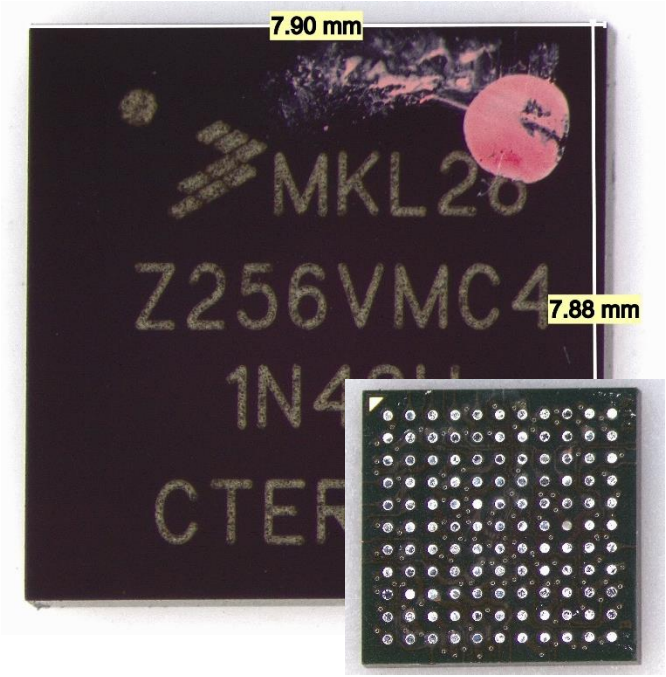
- Device manufacturers often use cryptographic mechanisms to vendor-lock accessories
- Third parties want to break these mechanisms to sell compatible accessories
- Let's see how this played out in one specific situation…

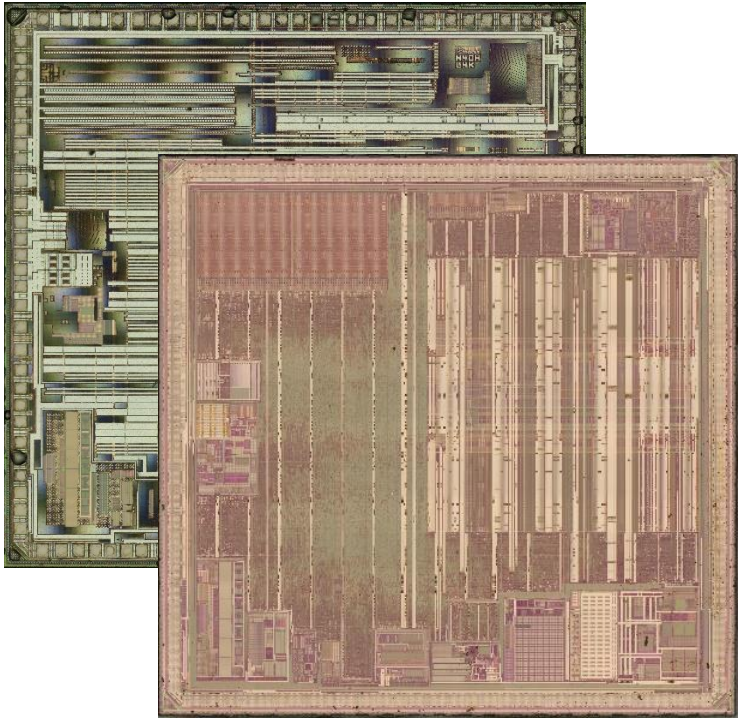
Case Study Overview

- Widely deployed (tens of millions sold) [redacted]
  - Multiple hardware generations
  - Two in particular are interesting to us
- Third party [redacted] exist on the market
  - Released shortly after major OEM hardware redesign
  - I wonder why?
- Let's dig deeper!

Old gen OEM product

- Freescale KL28 MCU





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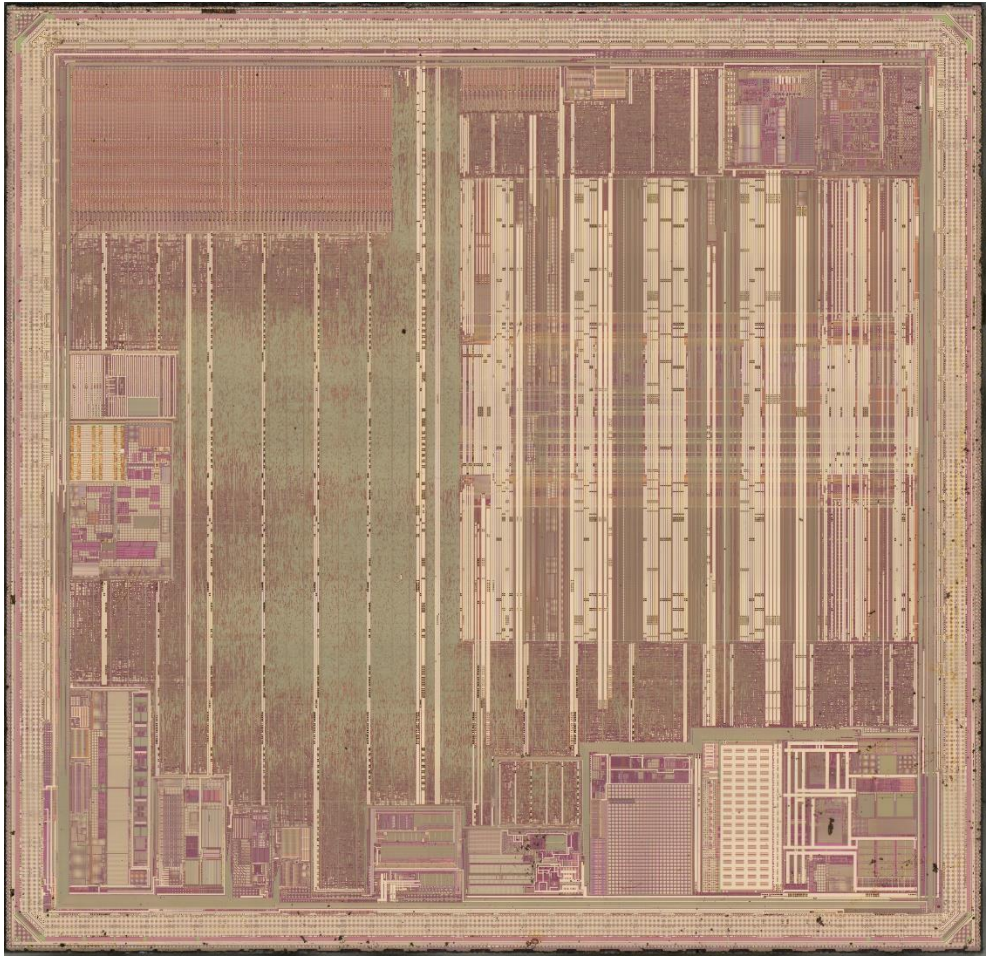
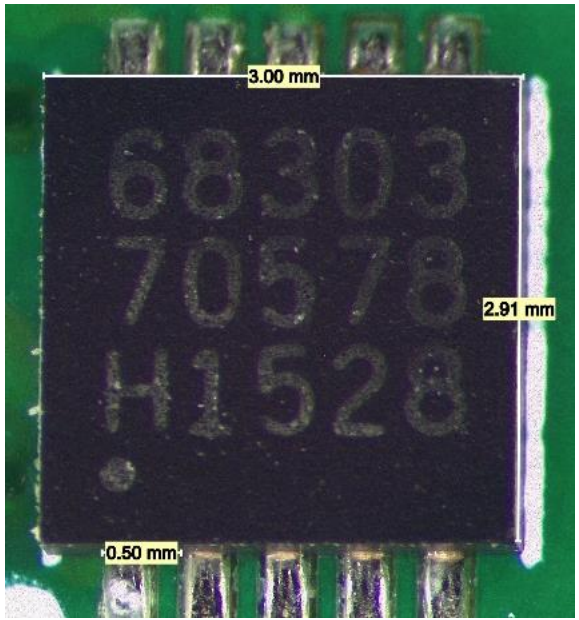
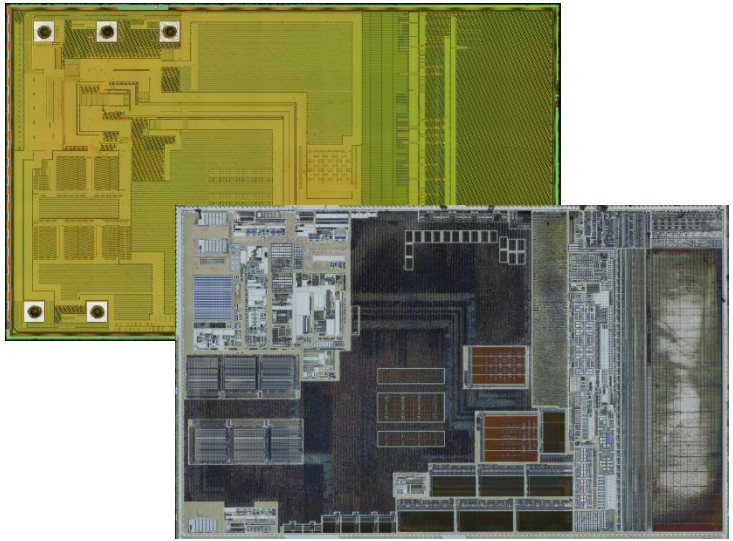


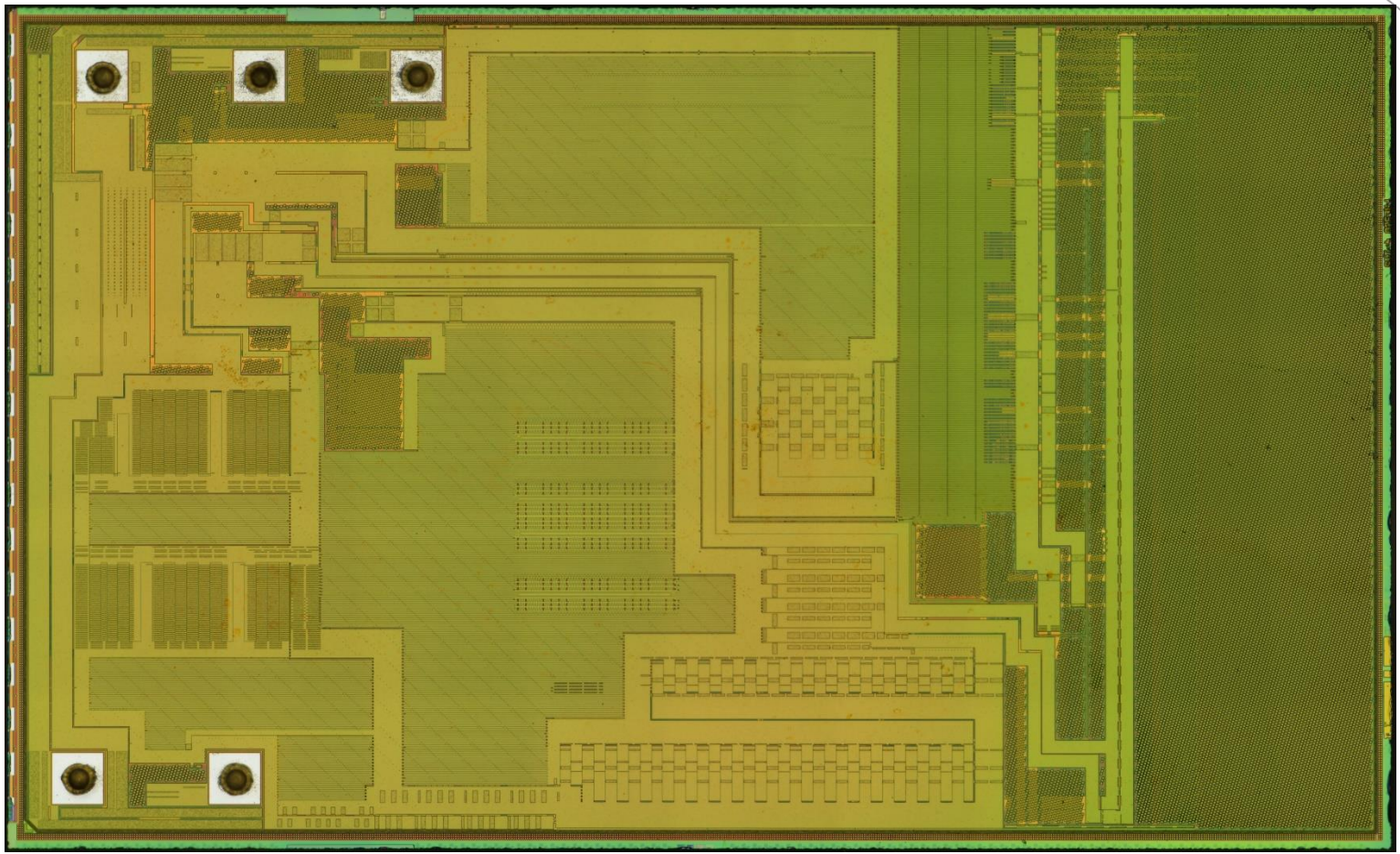
- Not super interesting
- Keys are elsewhere

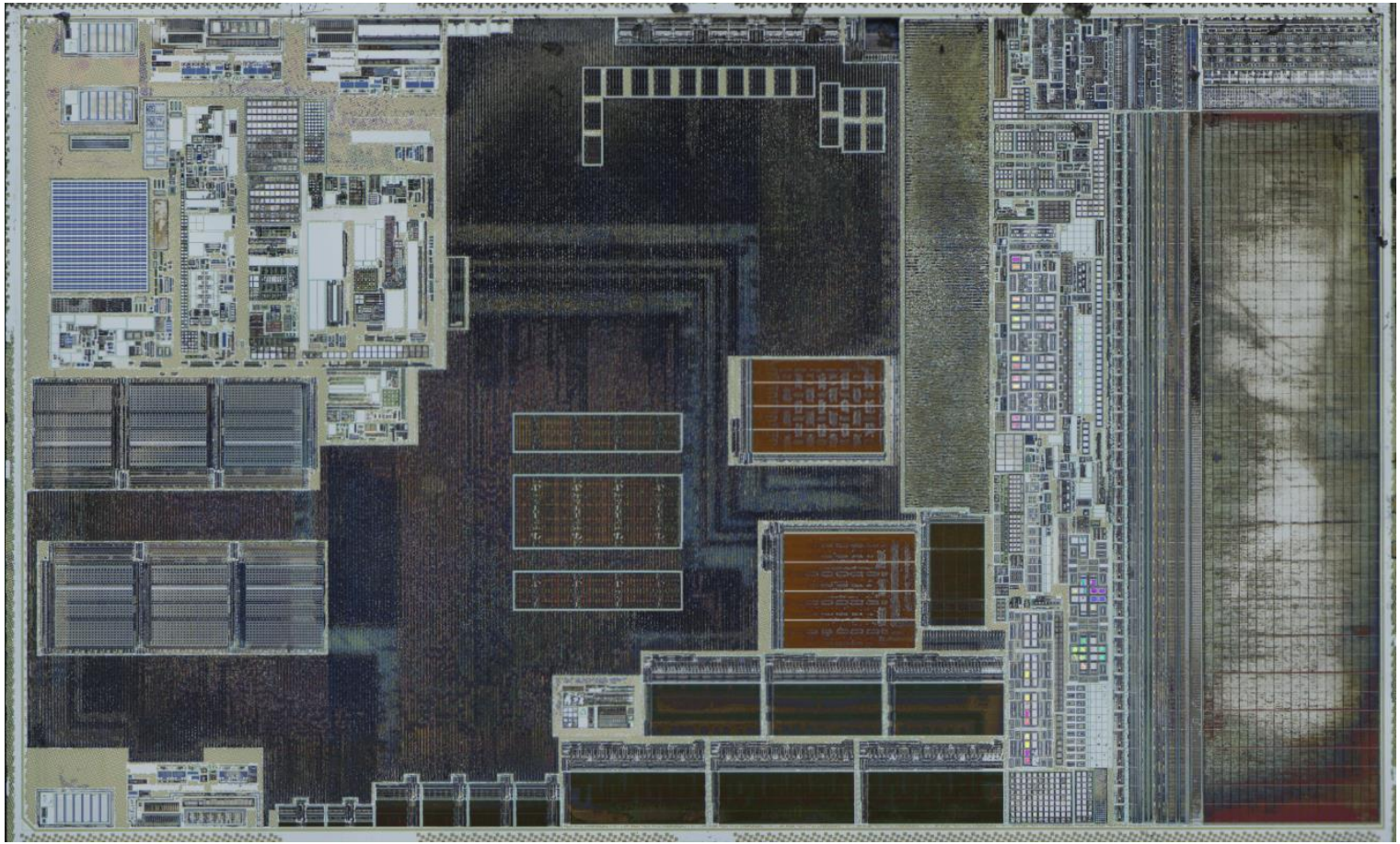
Old gen OEM product

- Infineon secure element



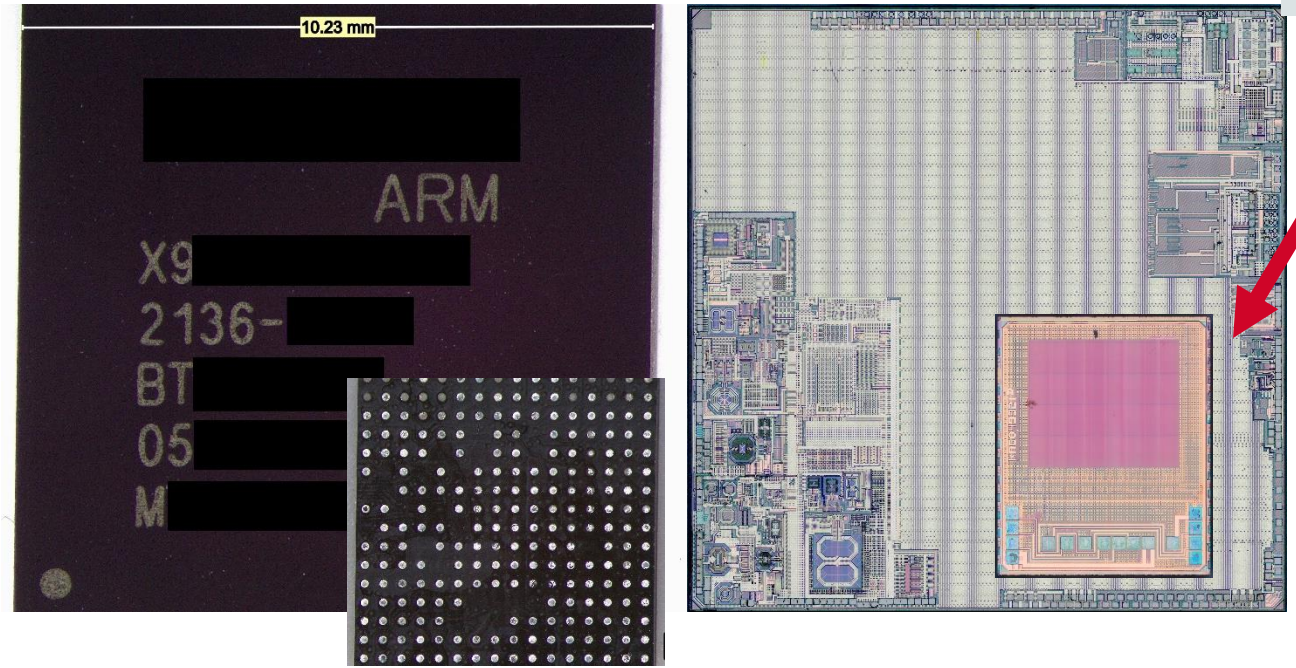






New gen OEM product

- All in one SoC with OEM branding



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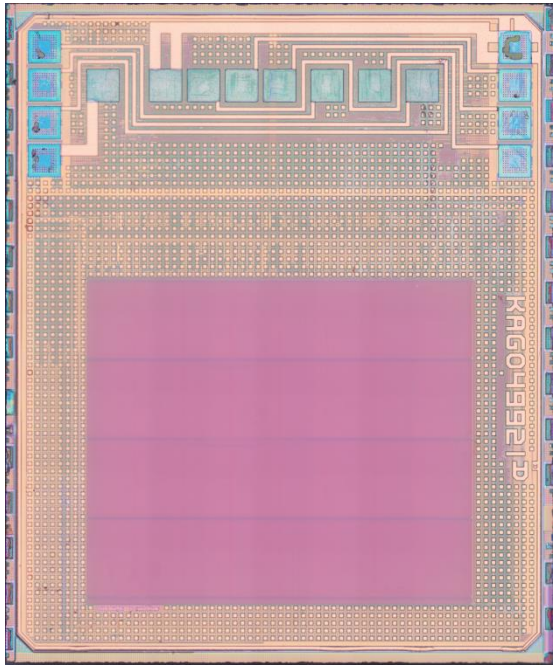
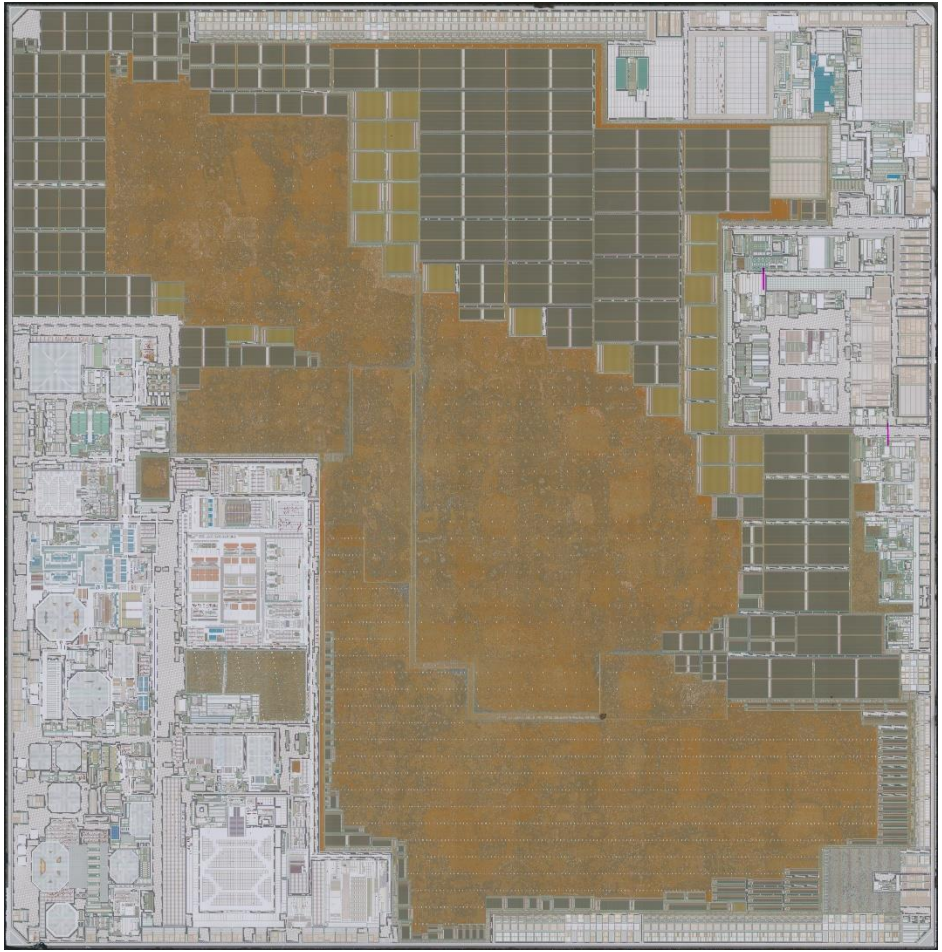
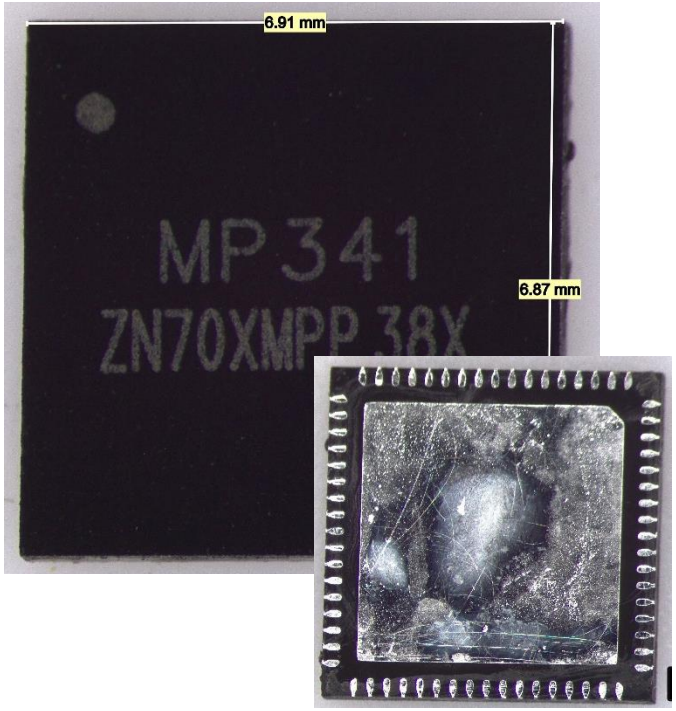


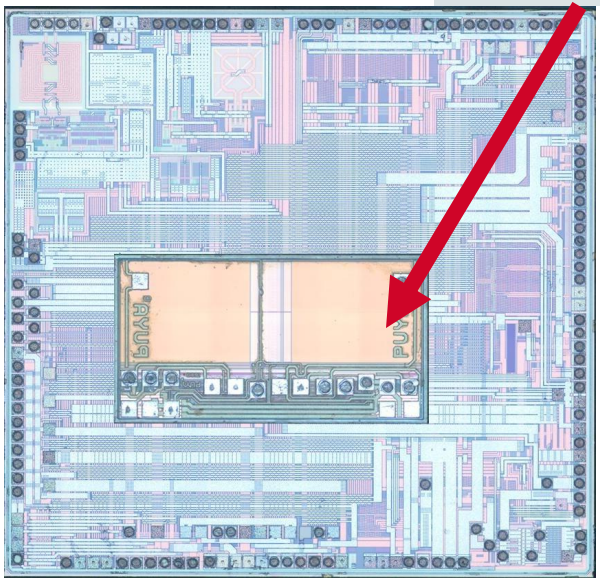


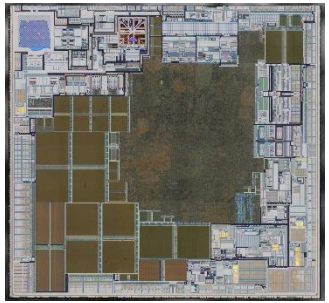
Third party

- Unidentified 55nm MCU

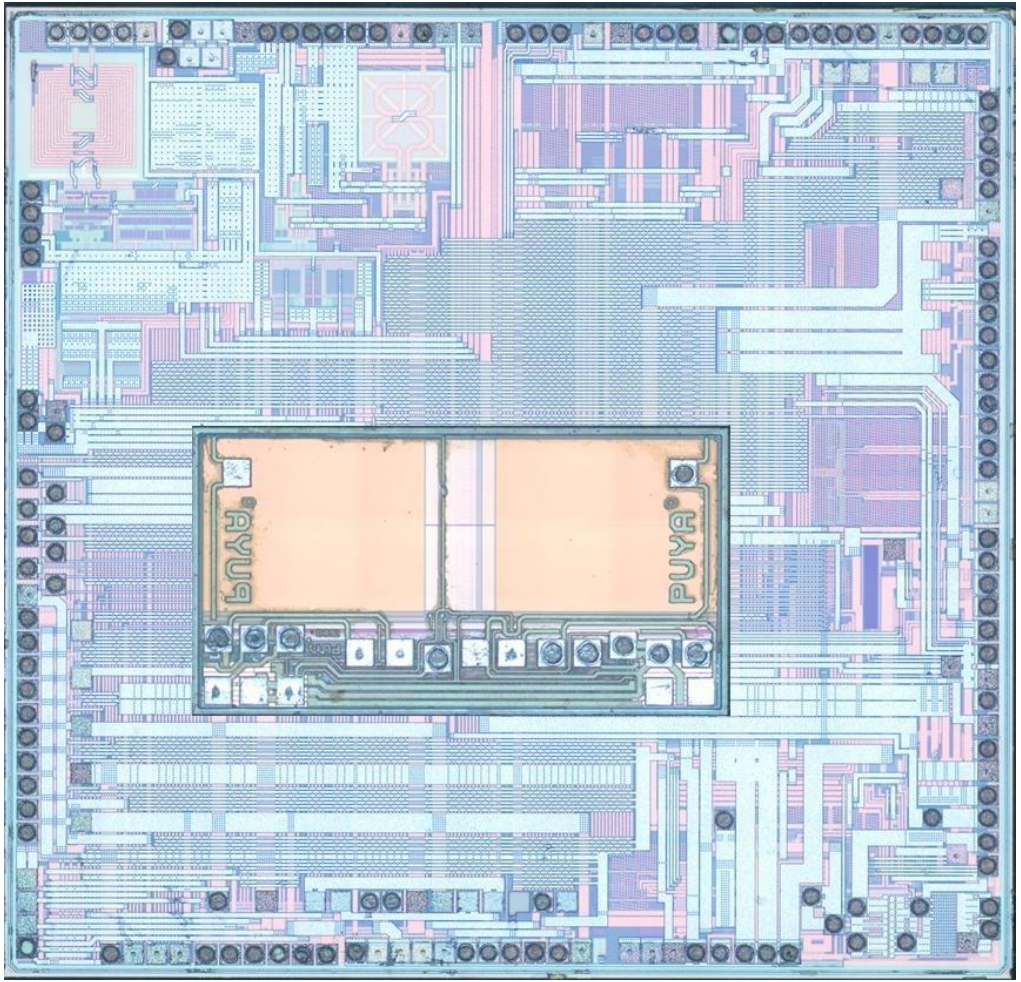


Stacked die
SPI flash

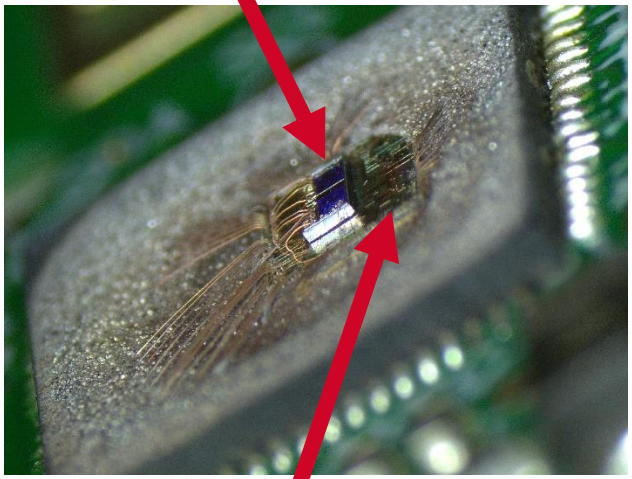




IOActive.

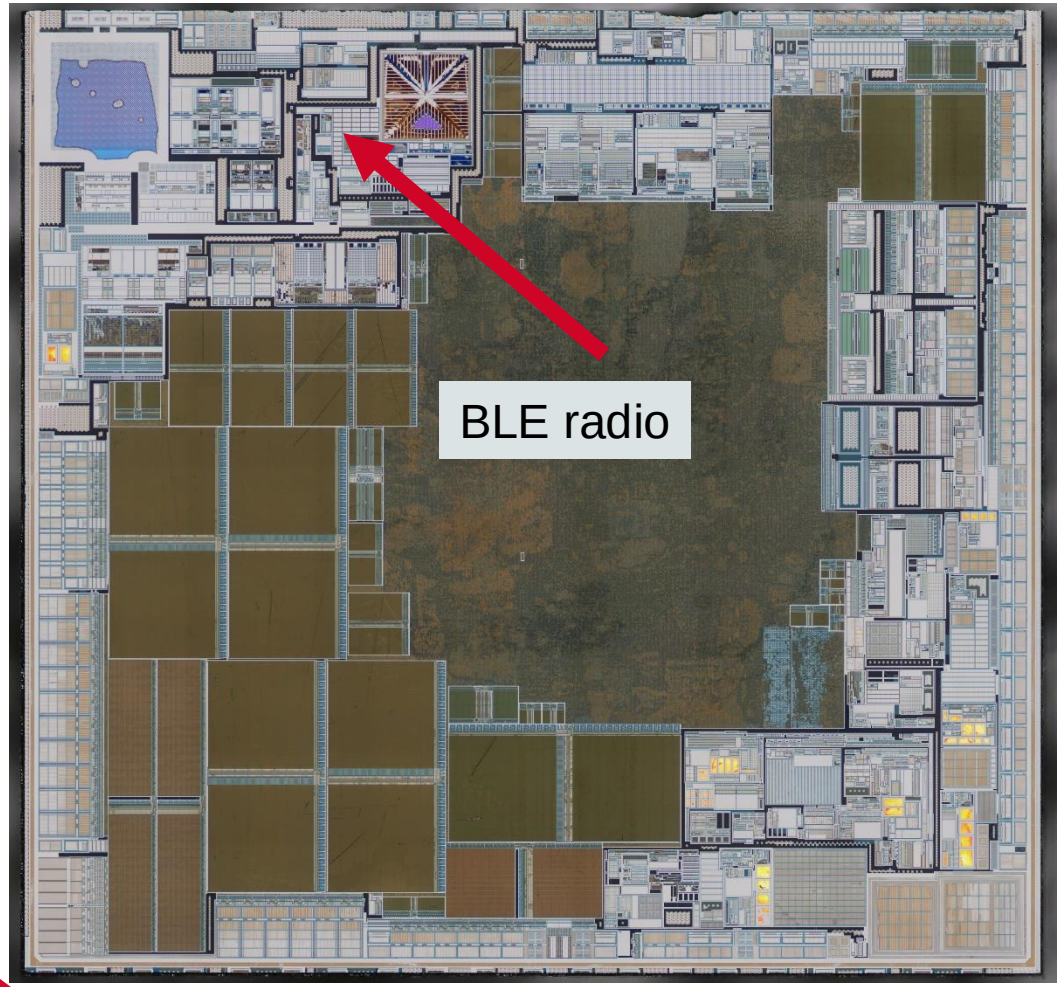


Flash die



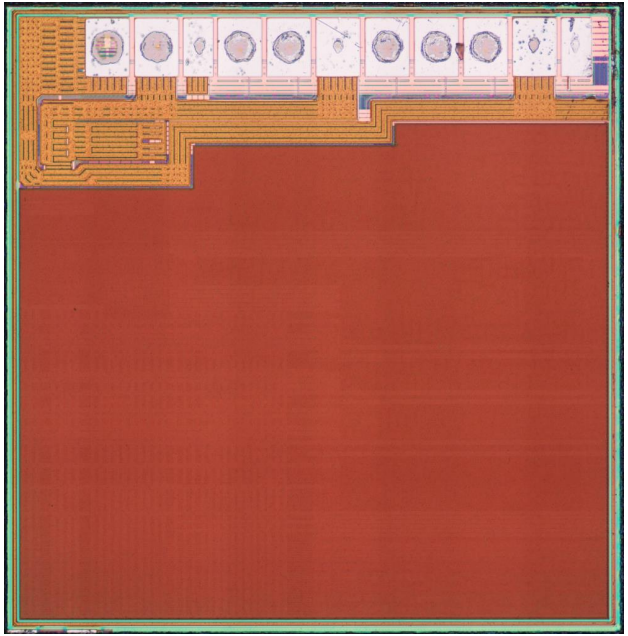
Logic die

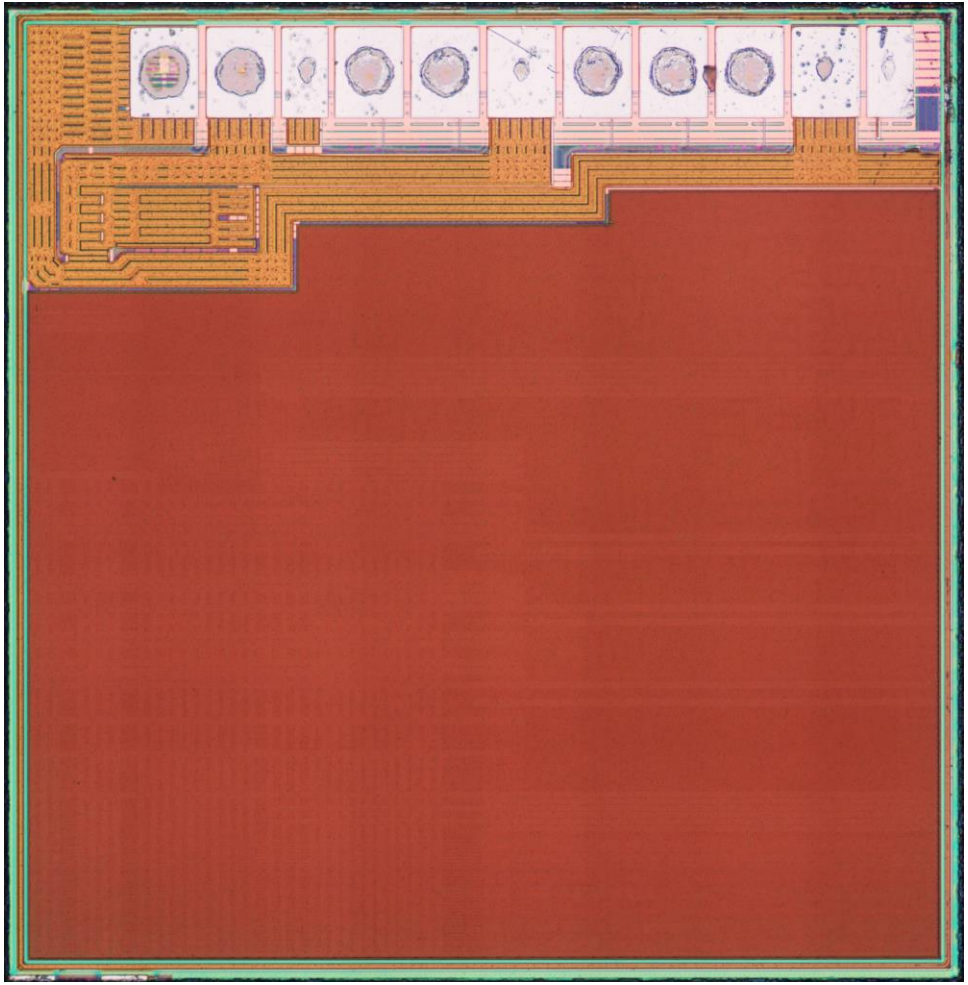
IOActive.

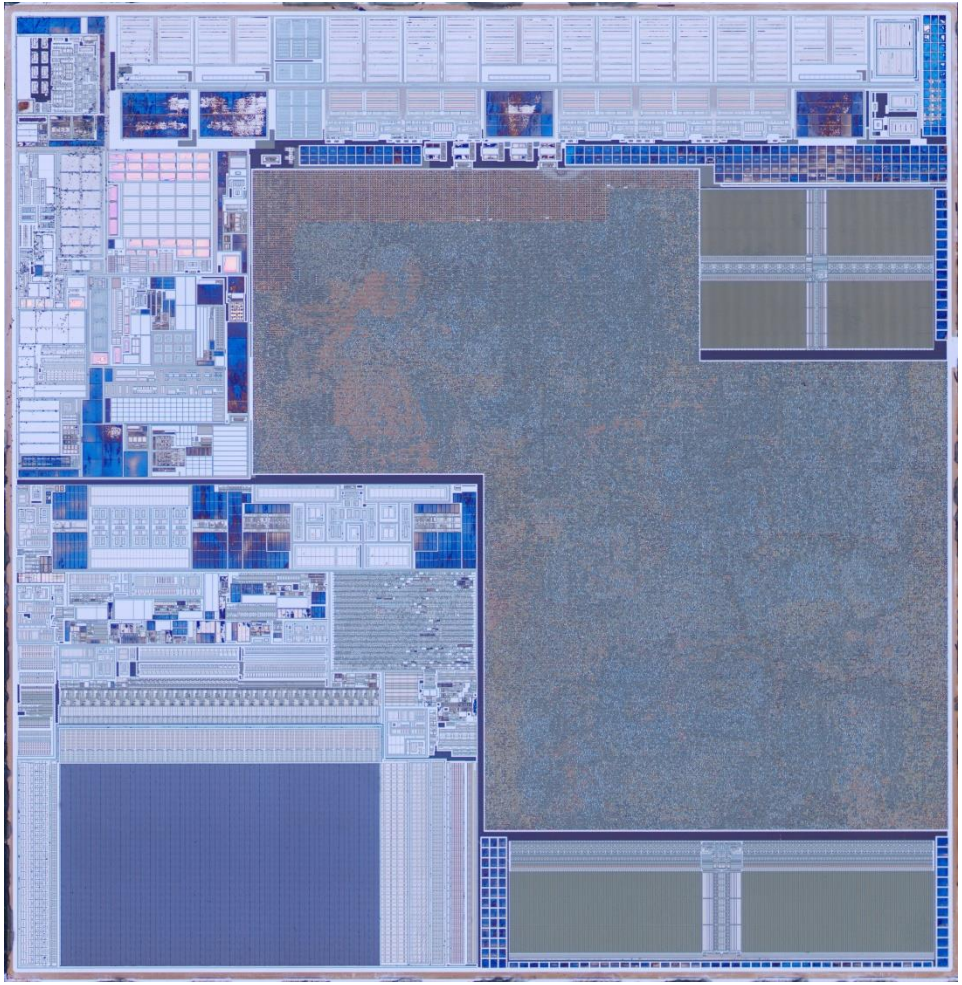


Third party

- Unidentified 55nm secure element



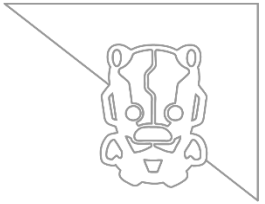




But why a secure element on the clone?

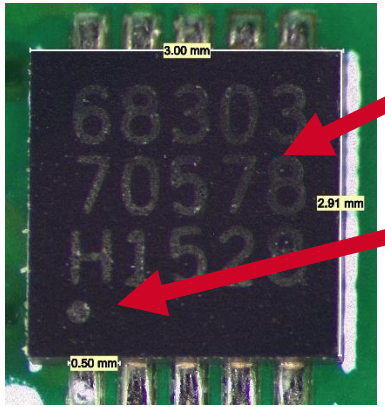
- Didn’t make a whole lot of sense to us at first
  - Just put the key in flash on your MCU
  - Crypto libraries etc work fine on a regular MCU

But why a secure element on the clone?



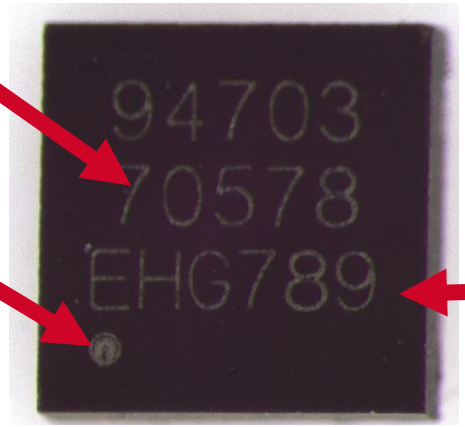
- Didn’t make a whole lot of sense to us at first
  - Just put the key in flash on your MCU
  - Crypto libraries etc work fine on a regular MCU
- Unless… you want the clone market to yourself!

Secure Elements

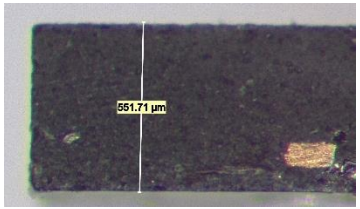


Same number

Shape of pin 1 mark

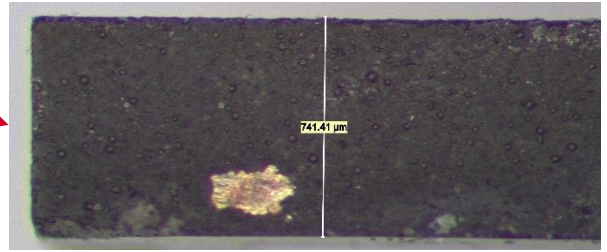


Lighter font



Old gen OEM

Thicker package



Third party

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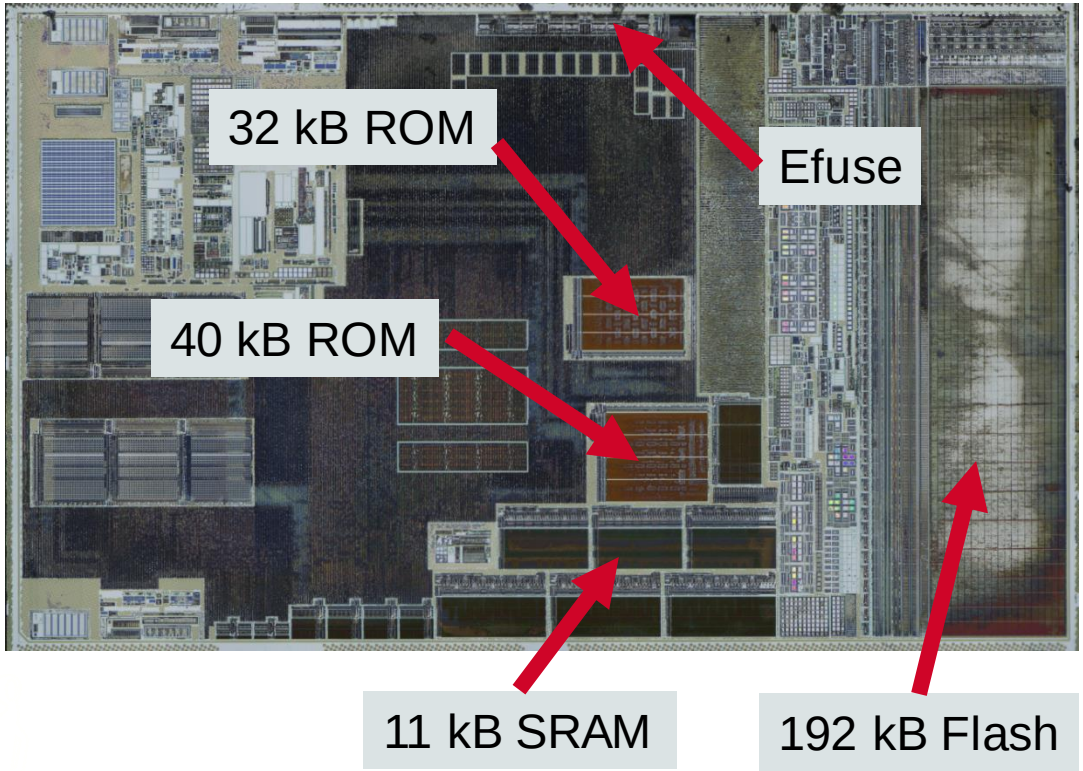
Why so similar?

- They're not "counterfeits"
  - No chance of tricking the OEM into buying this

Why so similar?

- They're not "counterfeits"
  - No chance of tricking the OEM into buying this
- Working theory: Fourth party pwned OEM chipset
  - They want royalties on the clone market
  - Sell pre-keyed SE's to unlicensed accessory vendors
  - Use similar markings so prospective buyers recognize it

Old gen OEM: secure element



- 3.42 mm^2
- 90 nm
- BEOL: 4 Cu + 1 Al
- ≈ 475 kGate

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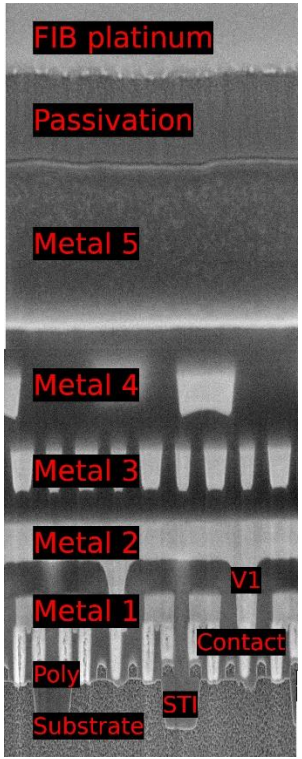
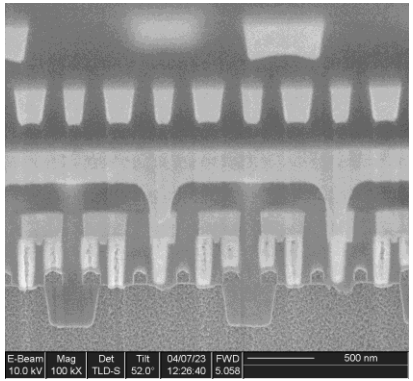
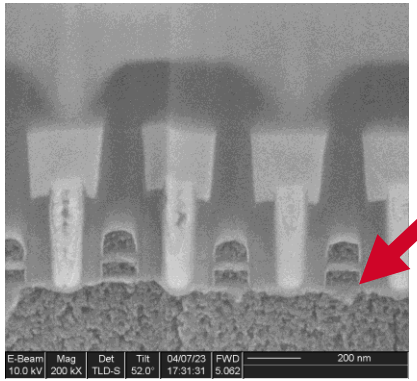
Old gen OEM SE: Cross section



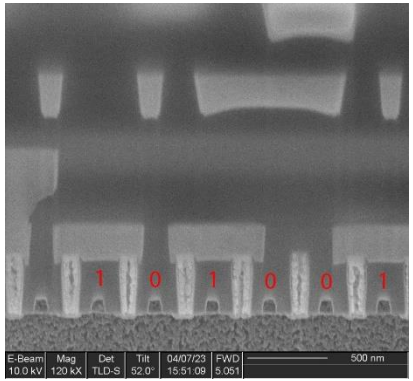


SRAM PMOS



Flash

Floating gates



ROM

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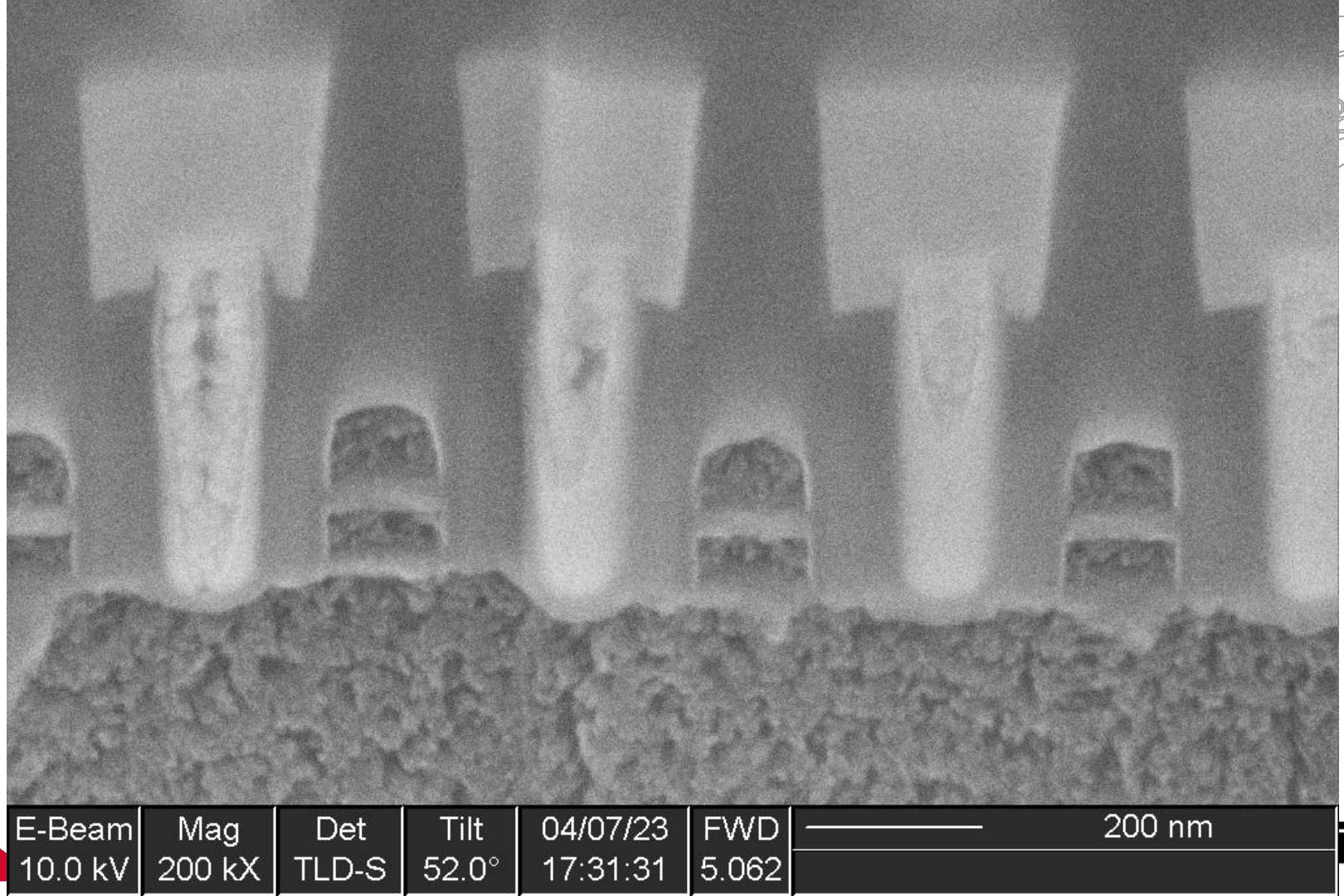
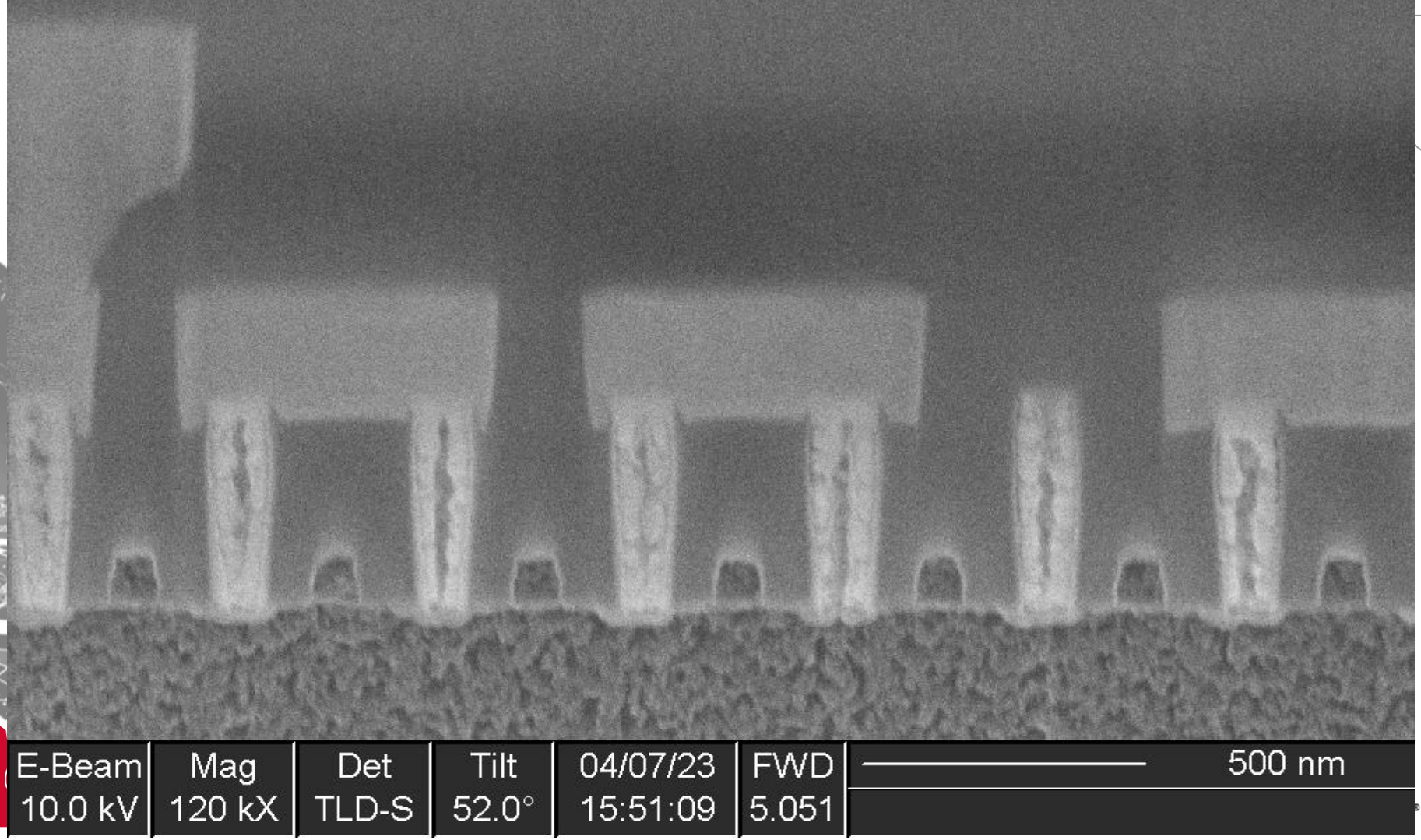
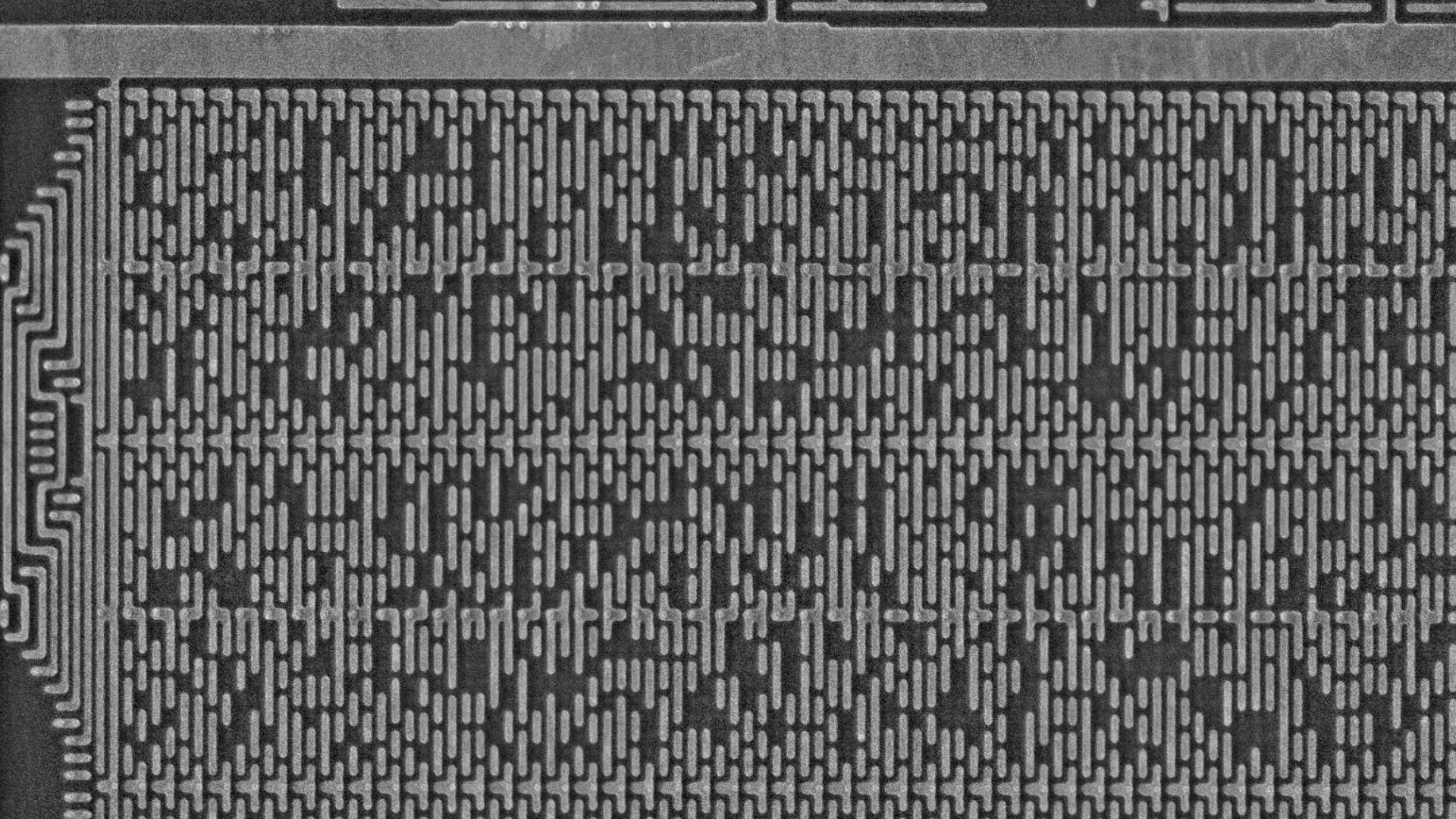
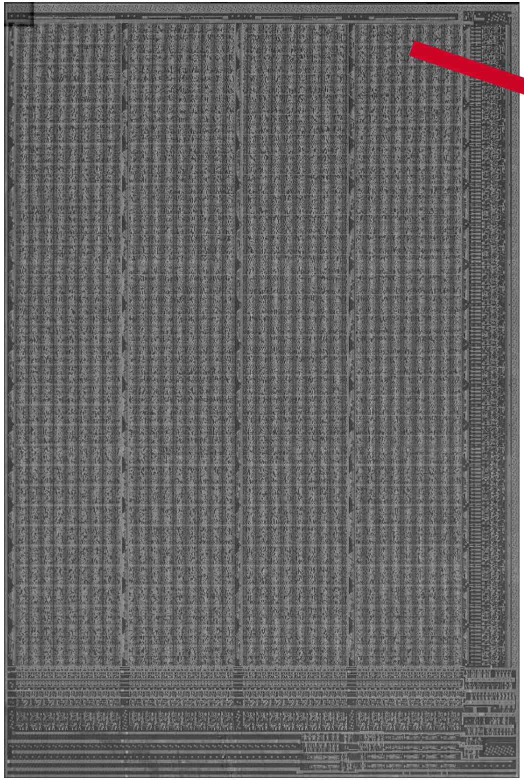
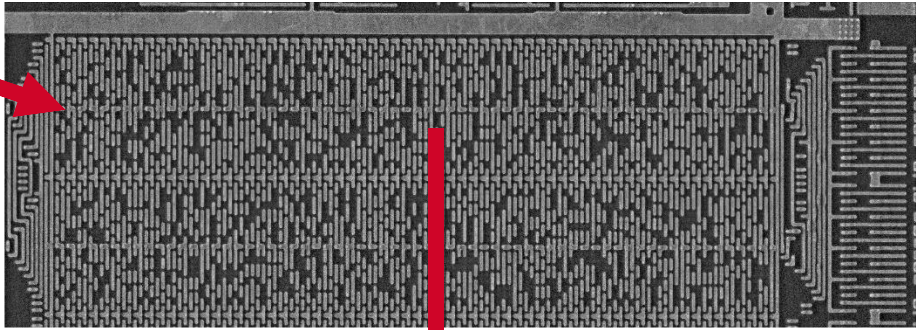

E-Beam
10.0 kV
Mag
200 kX
Det
TLD-S
Tilt
52.0°
04/07/23
17:31:31
FWD
5.062
200 nm


E-Beam
10.0 kV
Mag
120 kX
Det
TLD-S
Tilt
52.0°
04/07/23
15:51:09
FWD
5.051
500 nm



Old gen OEM SE: M1 ROM extraction





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00010110010100001101101111011100110111010000100010001001101000111101000010010011100111010001010001101100010001101100010110110010

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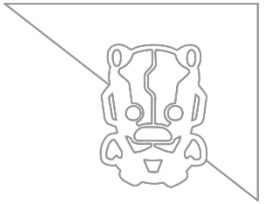
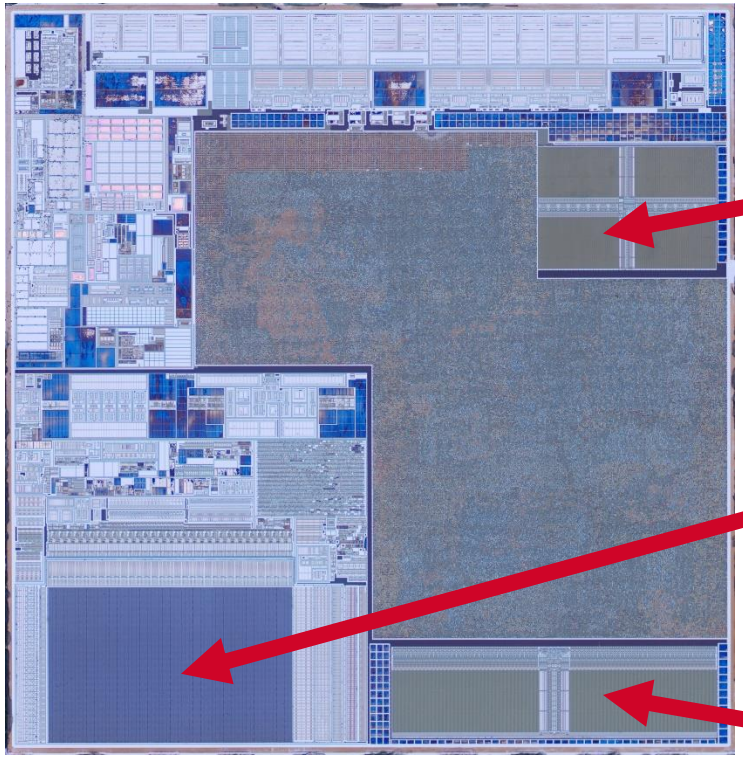
Old gen OEM SE: M1 ROM



- It’s encrypted ☹
- Didn’t find/reverse decryption logic
- Likely not how the cloner got in

Third party: secure element



- 1.28 mm^2
- 55 nm
- BEOL: 5 Cu + 1 Al
- ≈ 450 kGate

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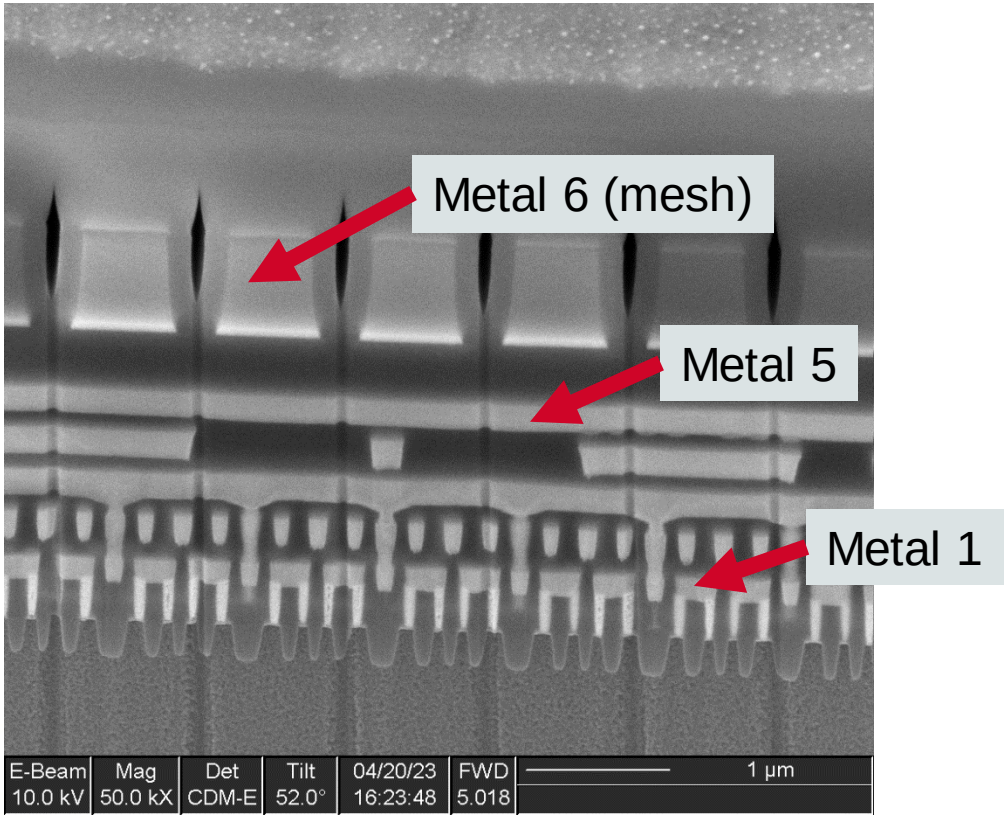
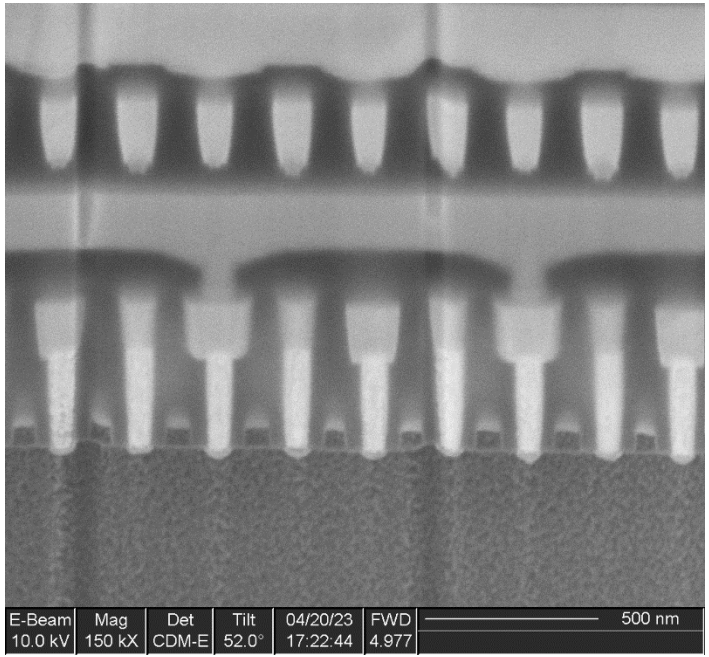
Third party secure element





SRAM NMOS

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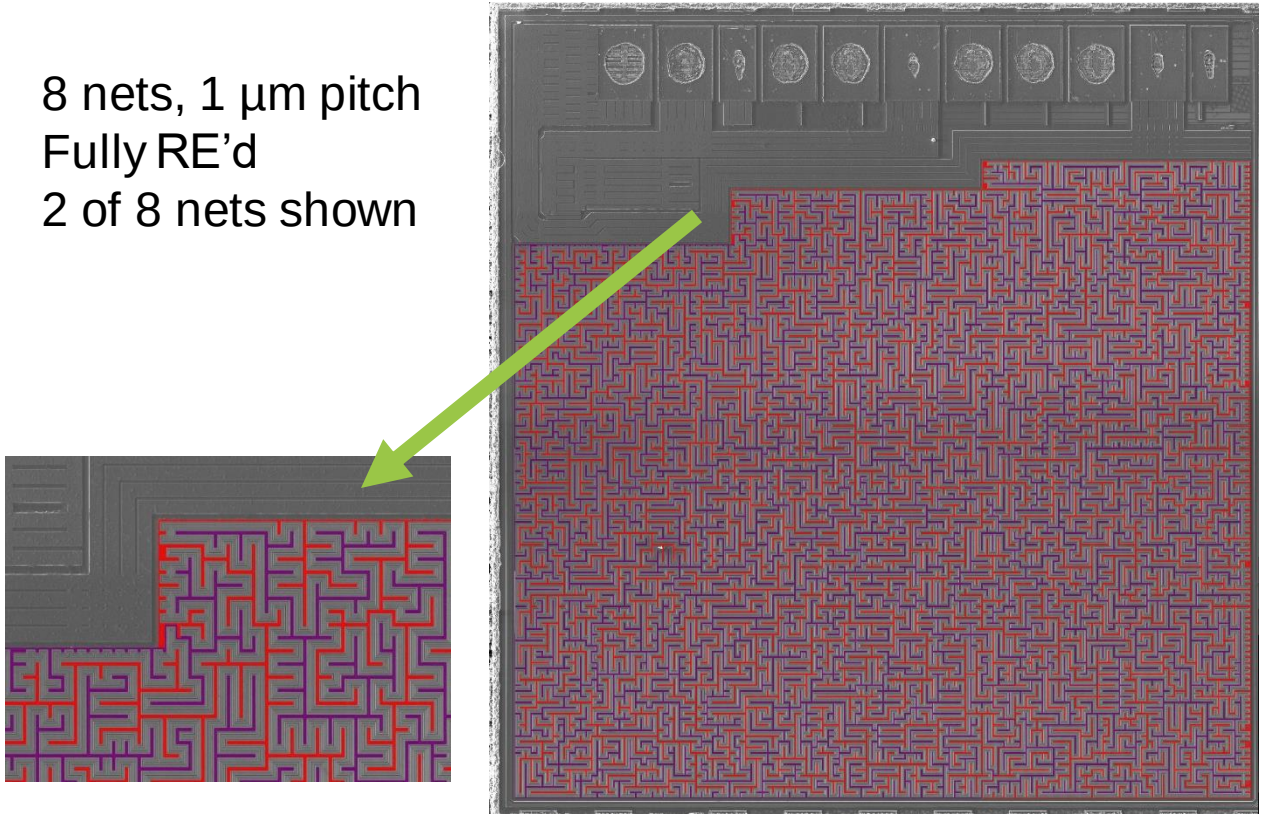
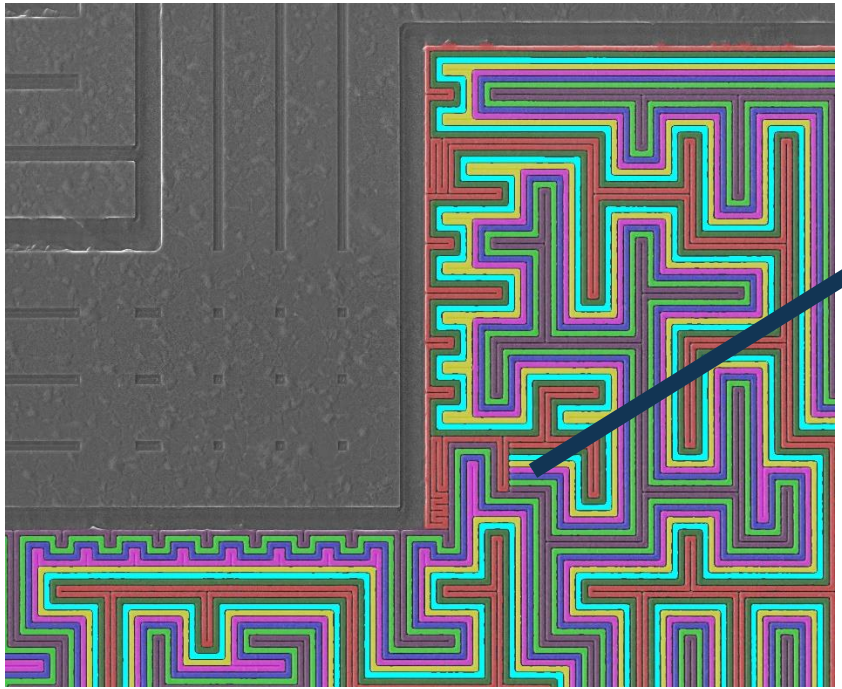
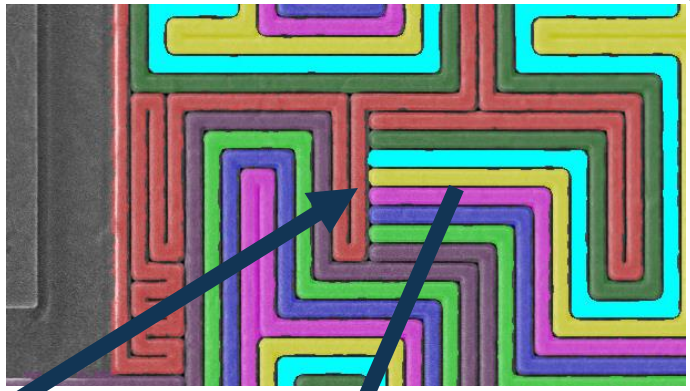
Third party secure element: Active mesh

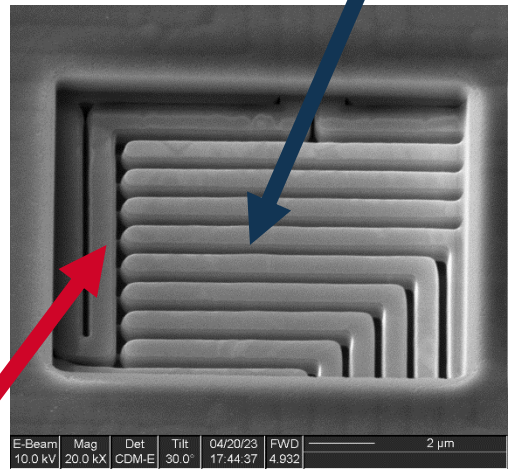
- 8 nets, 1 µm pitch
- Fully RE'd
- 2 of 8 nets shown



Security mesh tracing







Mesh end

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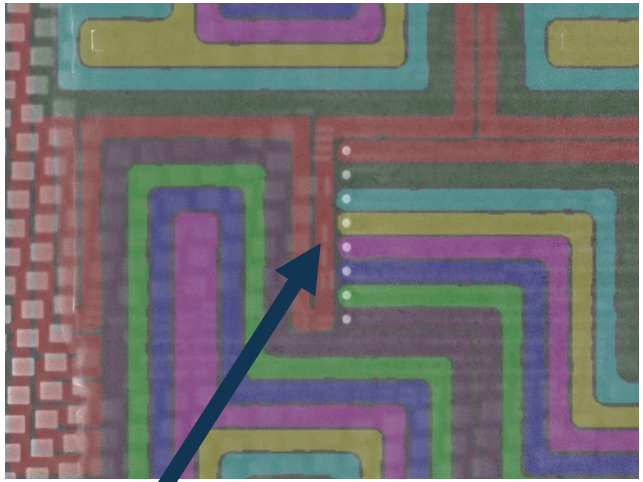
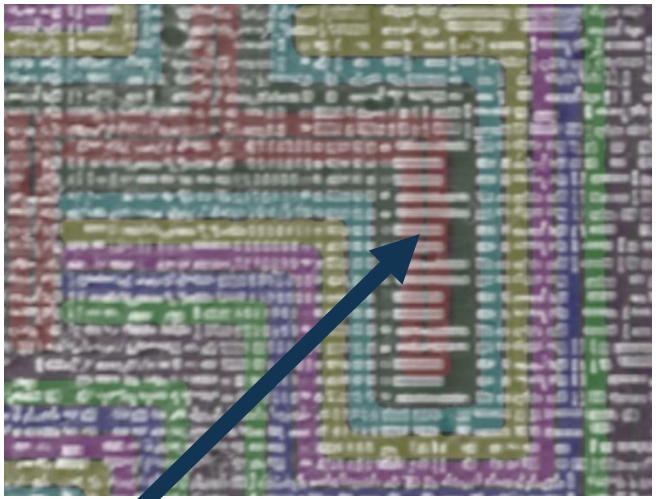
Security mesh drive logic



Vias to M5



8x high drive buffer cells

Overall conclusions

- OEM redesign introduced a weakness
  - Rapidly exploited by cloners
  - SPI flash probably contains the private key
- Original OEM design likely undefeated
- Cloners don’t like competition

Questions?