The Birth of MEMS

History of MEMS

- https://nanohub.org/resources/26536/download/History_of_MEMS_Presentation.pdf

Kulite semiconductors

- https://kulite.com/about/
- Anthony David Kurtz, founder and chief executive officer of Kulite Semiconductor

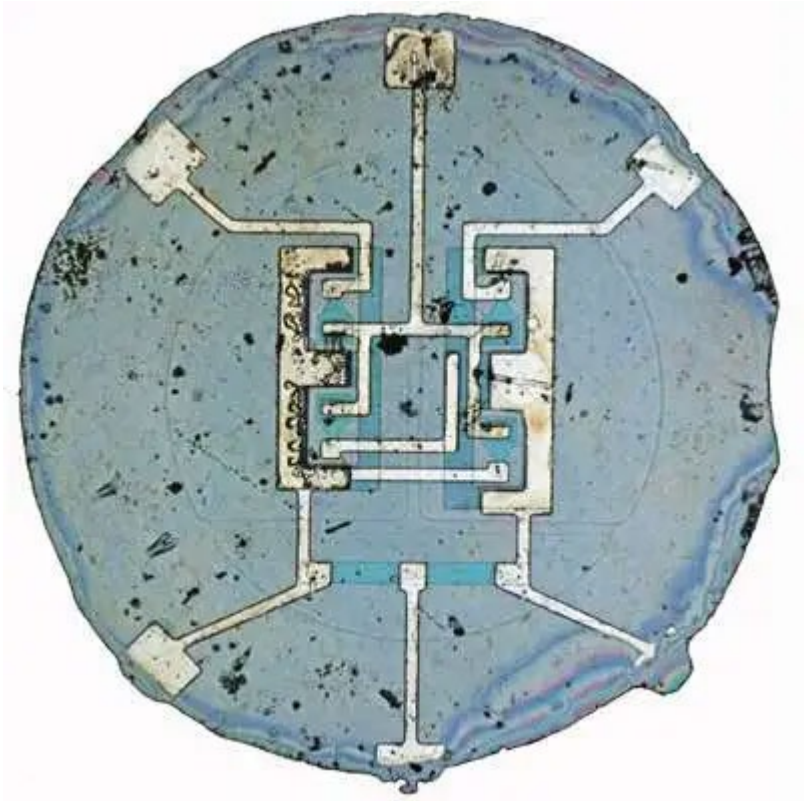
https://nap.nationalacademies.org/read/13338/chapter/29

His PhD thesis was titled “Mechanical properties of a newly promising element—silicon”

Small Business

under NAICS 336413

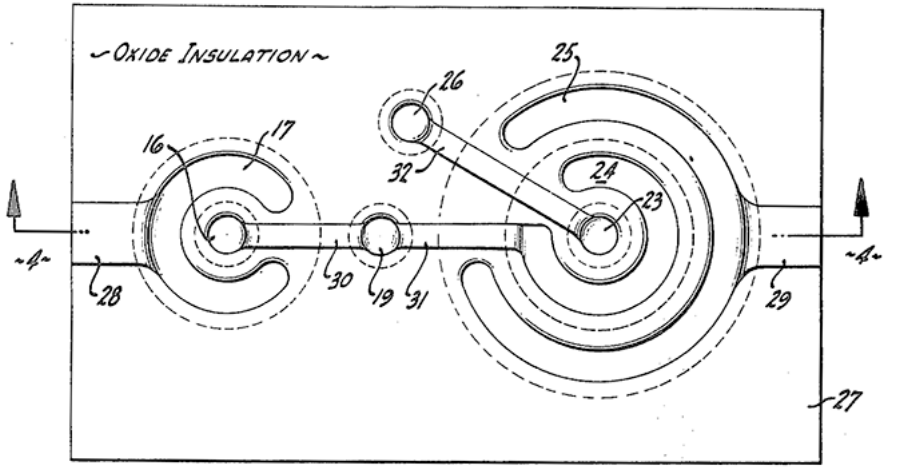
The very first IC



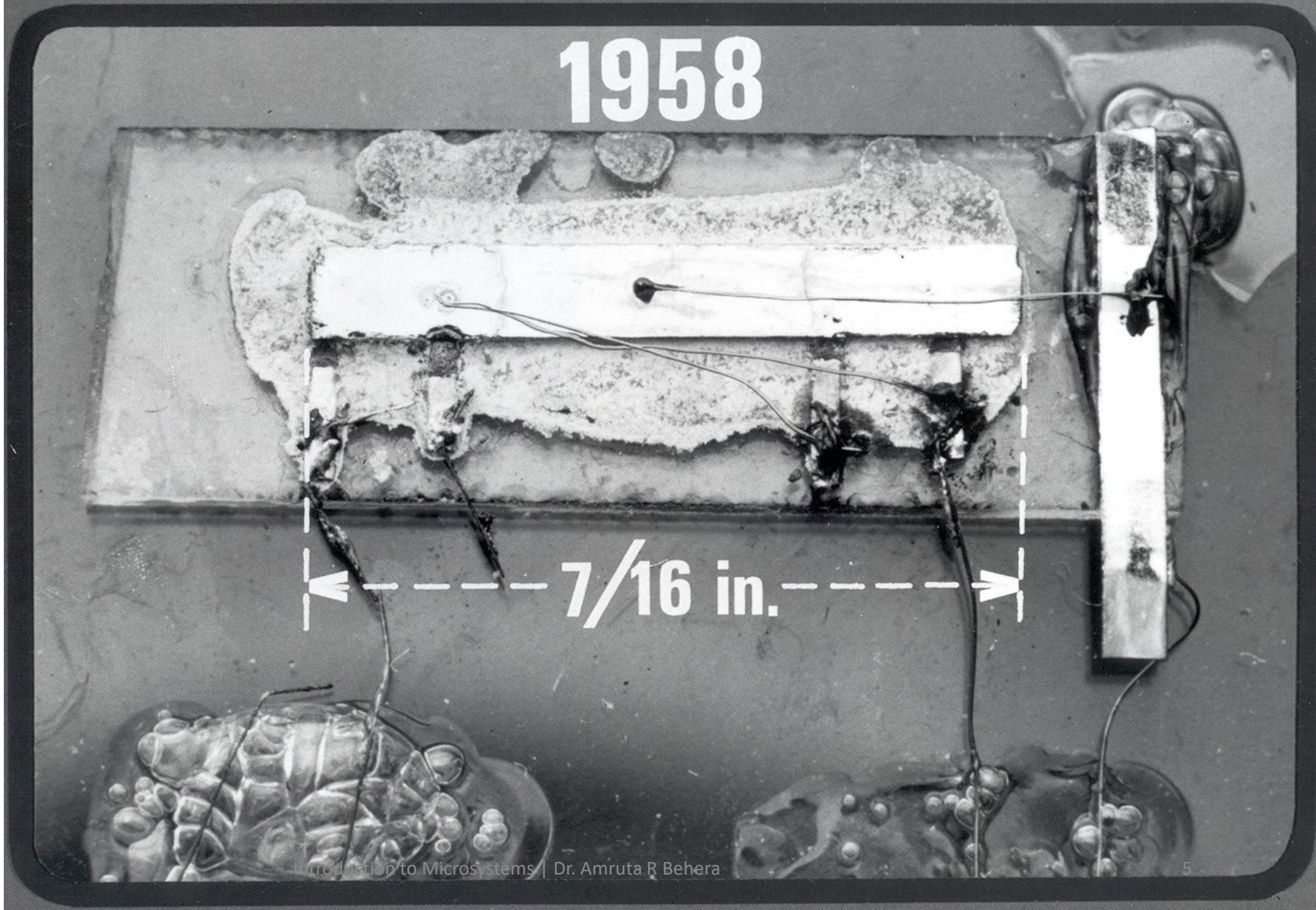
April 25, 1961 R. N. NOYCE 2,981,877

SEMICONDUCTOR DEVICE-AND-LEAD STRUCTURE

Filed July 30, 1959 3 Sheets-Sheet 2



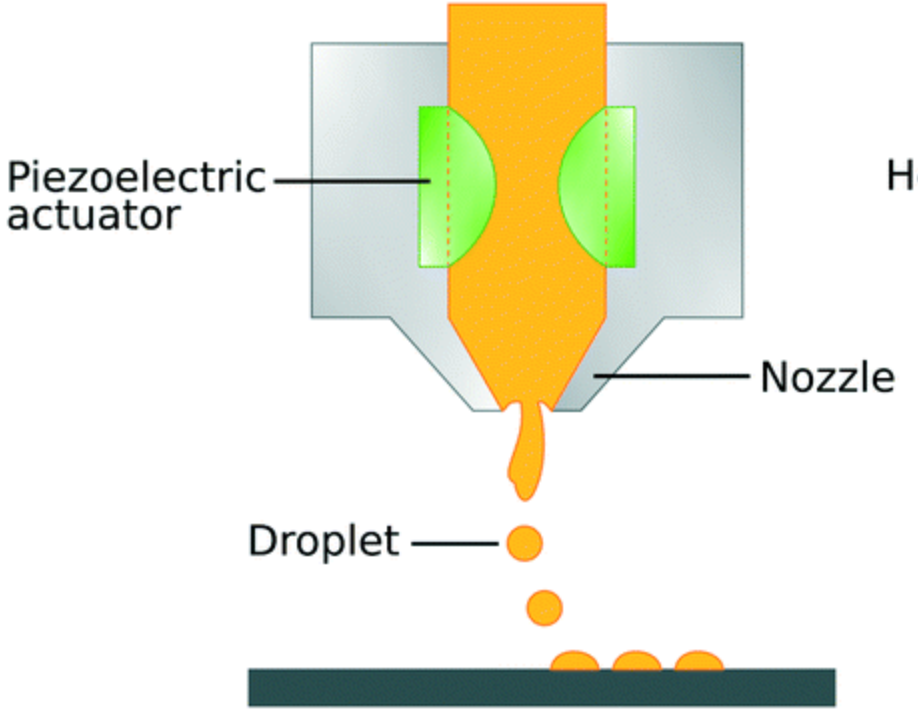
https://www.edn.com/noyce-receives-1st-ic-patent-april-25-1961/

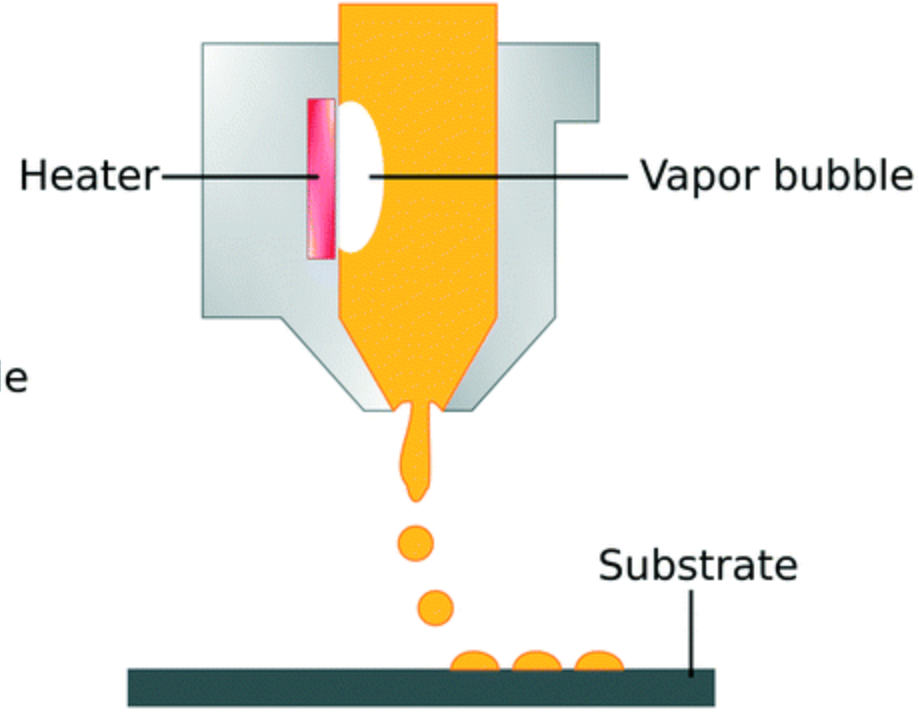


https://ntlab.lt/ic-history/

MEMS are desirable due to..

- Small sensors interfere less with the environment they are measuring than larger devices.
- Reduced cost due to batch production and miniaturization
- Better performance, e.g., Silicon piezoresistor is better than metals
- Greater complexity/functionality
- Low power consumption
- Small footprint at system level
- Redundancy



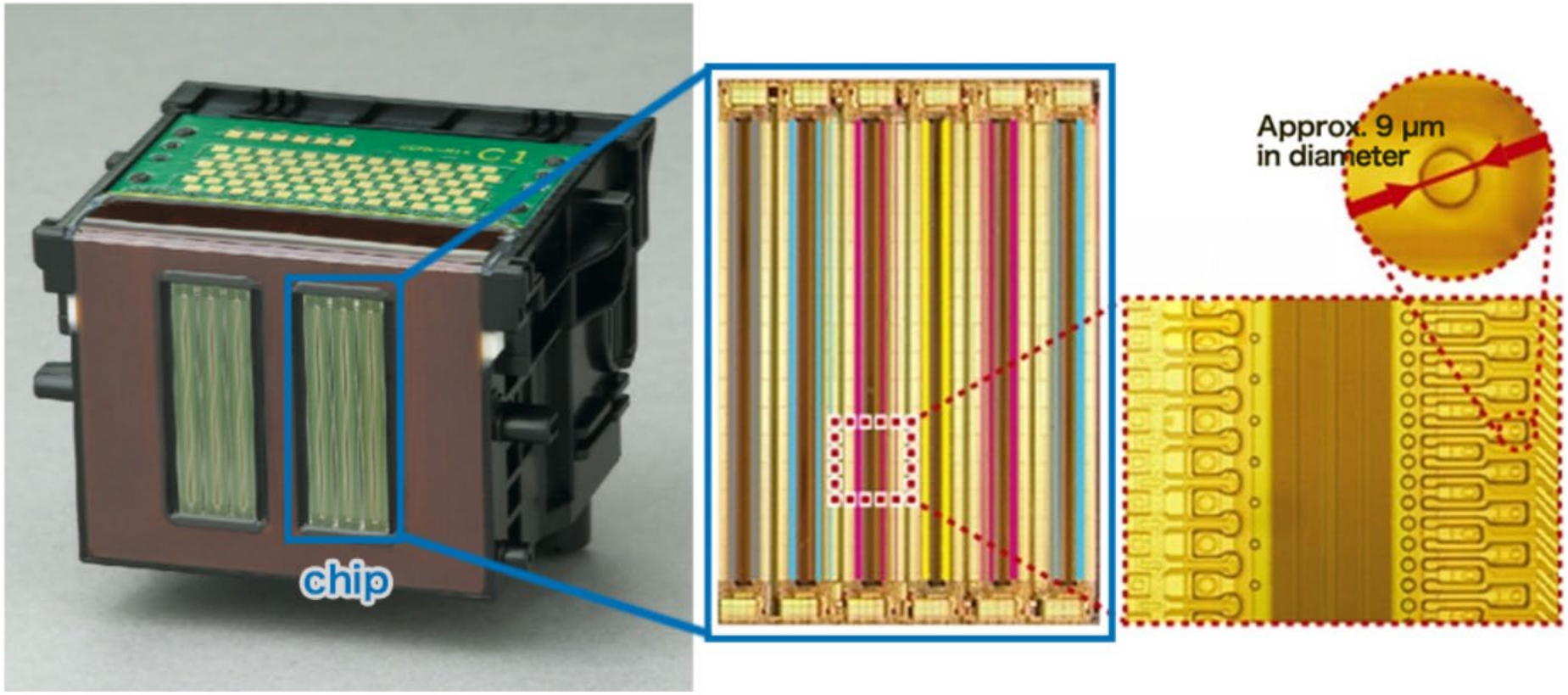


https://pubs.rsc.org/en/content/articlehtml/2020/cy/d0cy00040j

Inkjet printheads

Two key mechanisms

Inside a Canon's thermal printhead



Print Head with Enlarged View of Nozzle Configuration

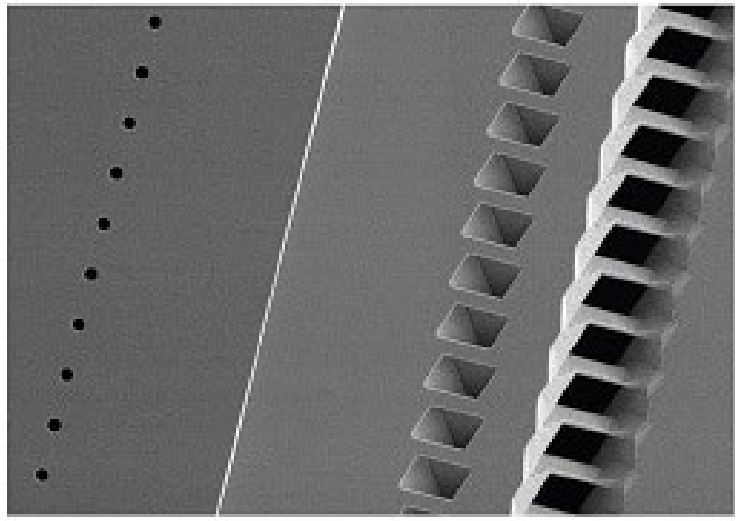
6,000 nozzles on a chip with an area measuring a mere 20 mm x 16 mm, roughly the size of a thumbprint

https://global.canon/en/technology/support06.html

Teardown

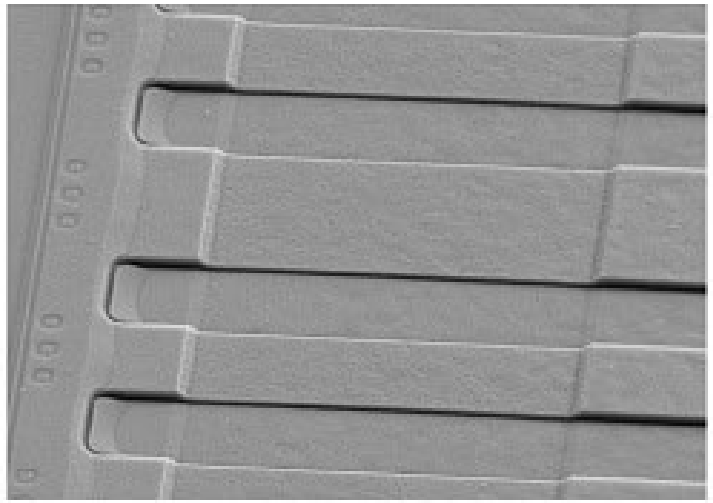
Channels etched in silicon – SEM view

(Source: Epson PrecisionCore Printhead with MicroTFP Inkjet Dies, System Plus Consulting, 2019)



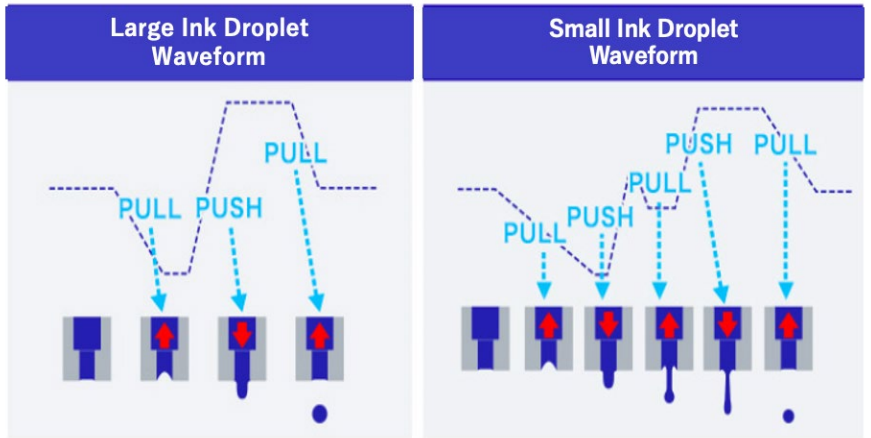
Small and large heater after organic layer removed SEM view

(Source: HP746 HDNA Inkjet Die from HP report, System Plus Consulting, 2019)



https://www.yolegroup.com/strategy-insights/inkjet-printhead-the-industry-is-driving-a-new-momentum/

Epson's piezo printhead



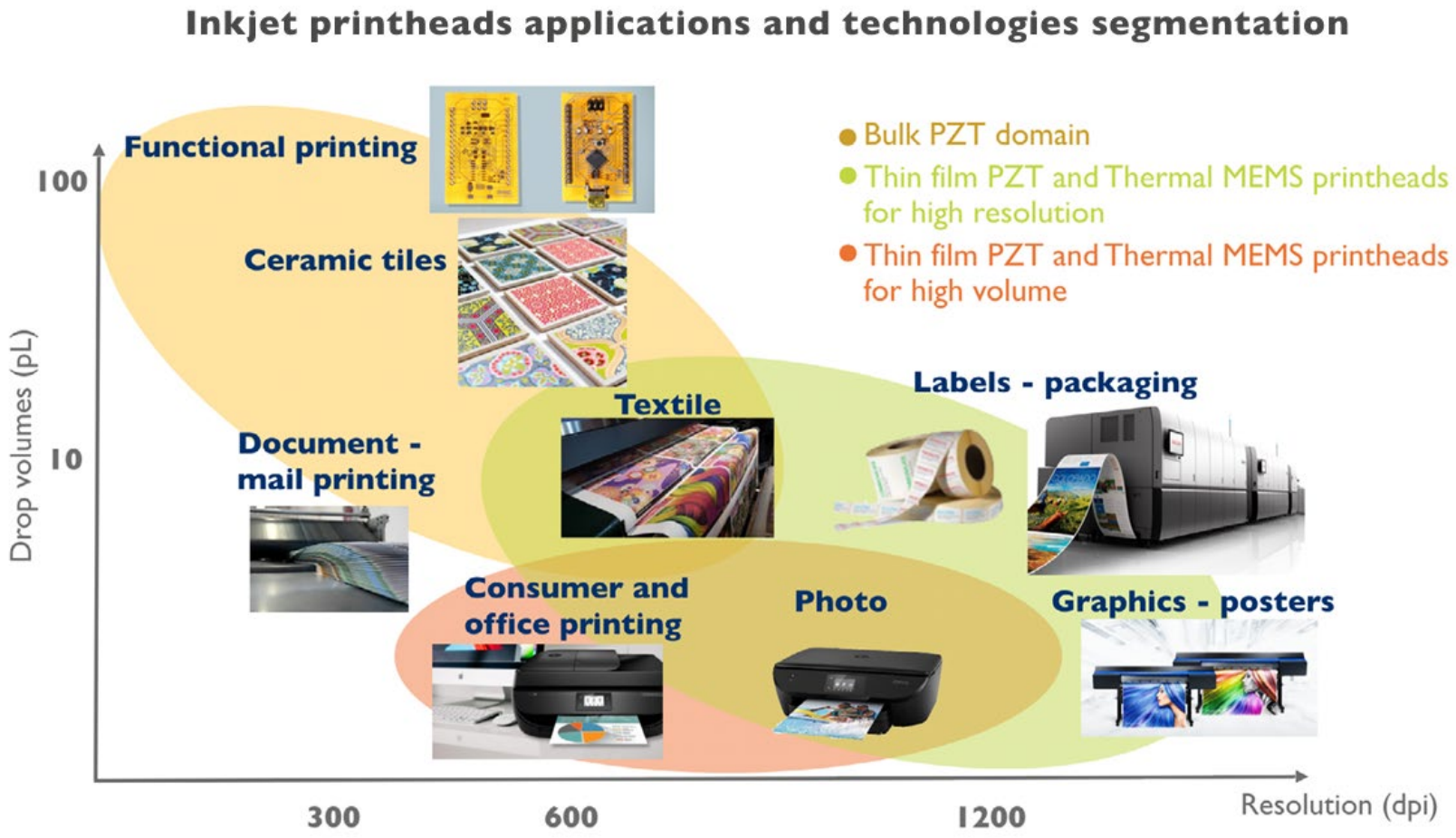
https://corporate.epson/en/technology/search-by-products/printer-inkjet/micro-piezo.html

	Production technology	Head cross-section nozzle pitch	Piezo distortion (ratio)
The First Generation Sintered piezo slurry Piezo element : 0.01mm Pressure chamber Nozzle	Precision Machining	120npi=0.21mm	1
The Second Generation MACH: Multilayer Piezo Piezo element Pressure chamber Nozzle	Precision Machining + MEMS	180npi=0.14mm	1.5
The Third Generation PrecisionCore Piezo element : 0.001mm Ink flow path Pressure chamber Nozzle	Thin-film + MEMS	Piezo distortion 300npi=0.08mm	2.5

MEMS:Micro Electro Mechanical Systems

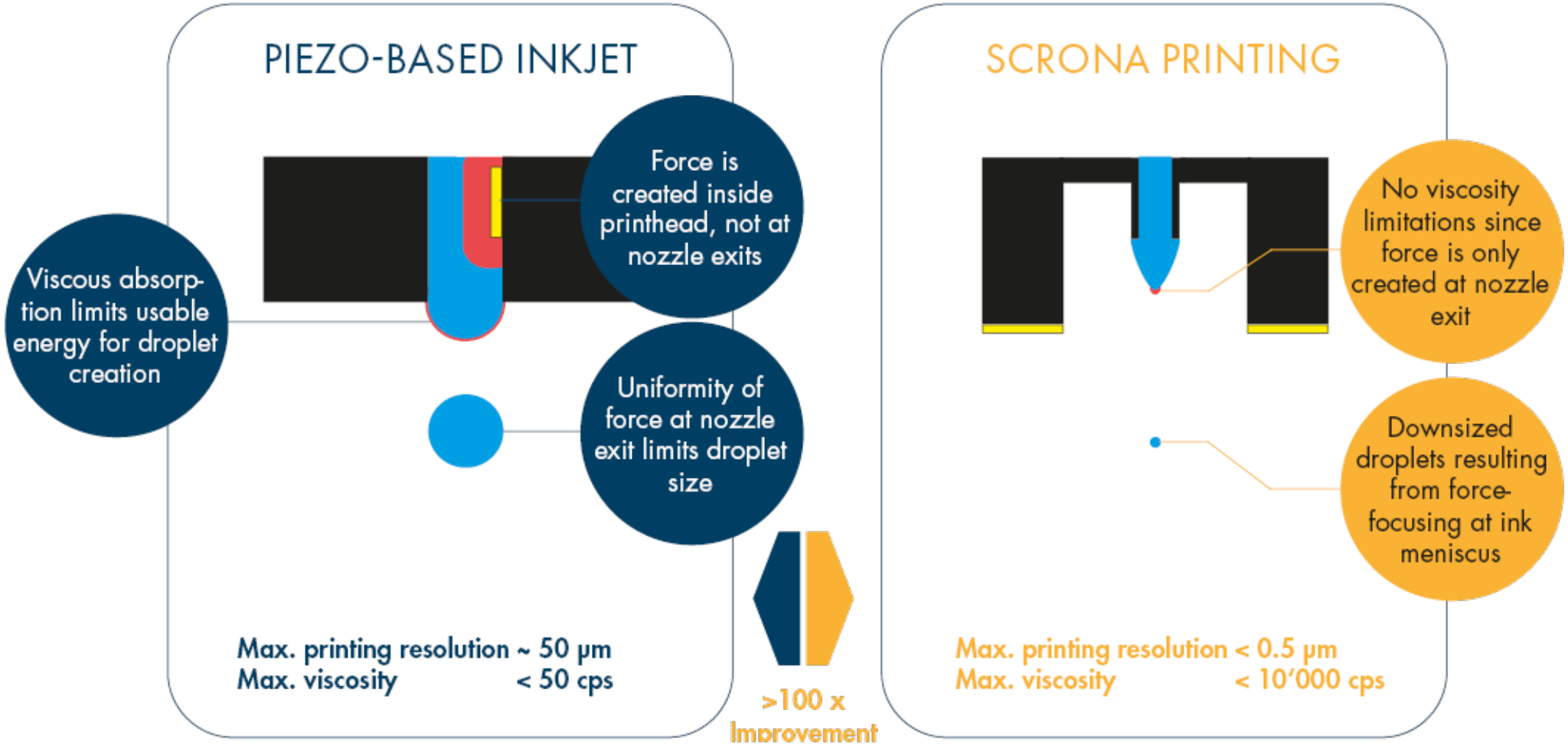
npi:nozzles per inch

Piezo MEMS based printheads market



https://medias.yolegroup.com/uploads/2019/08/Yole_YD19038_Inkjet-Printheads-Dispensing-Technologies-Market-Landscape-2019_flyer.pdf

Comparison between inkjet & EHD printing



[The physical principle]

[One of the patents]

[Inventor's work]

https://www.notion-systems.com/products/laboratory-equipment/n.jet-EHD.html

COMPARISON INKJET VS. EHD

SCRONA

Standard Inkjet

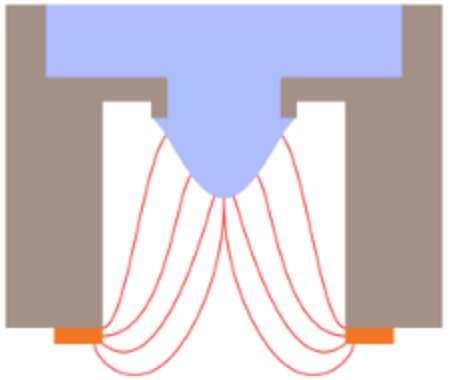
push from inside of nozzle

energy created inside PH mostly lost

Scrona EHD Inkjet

pull from outside of nozzle

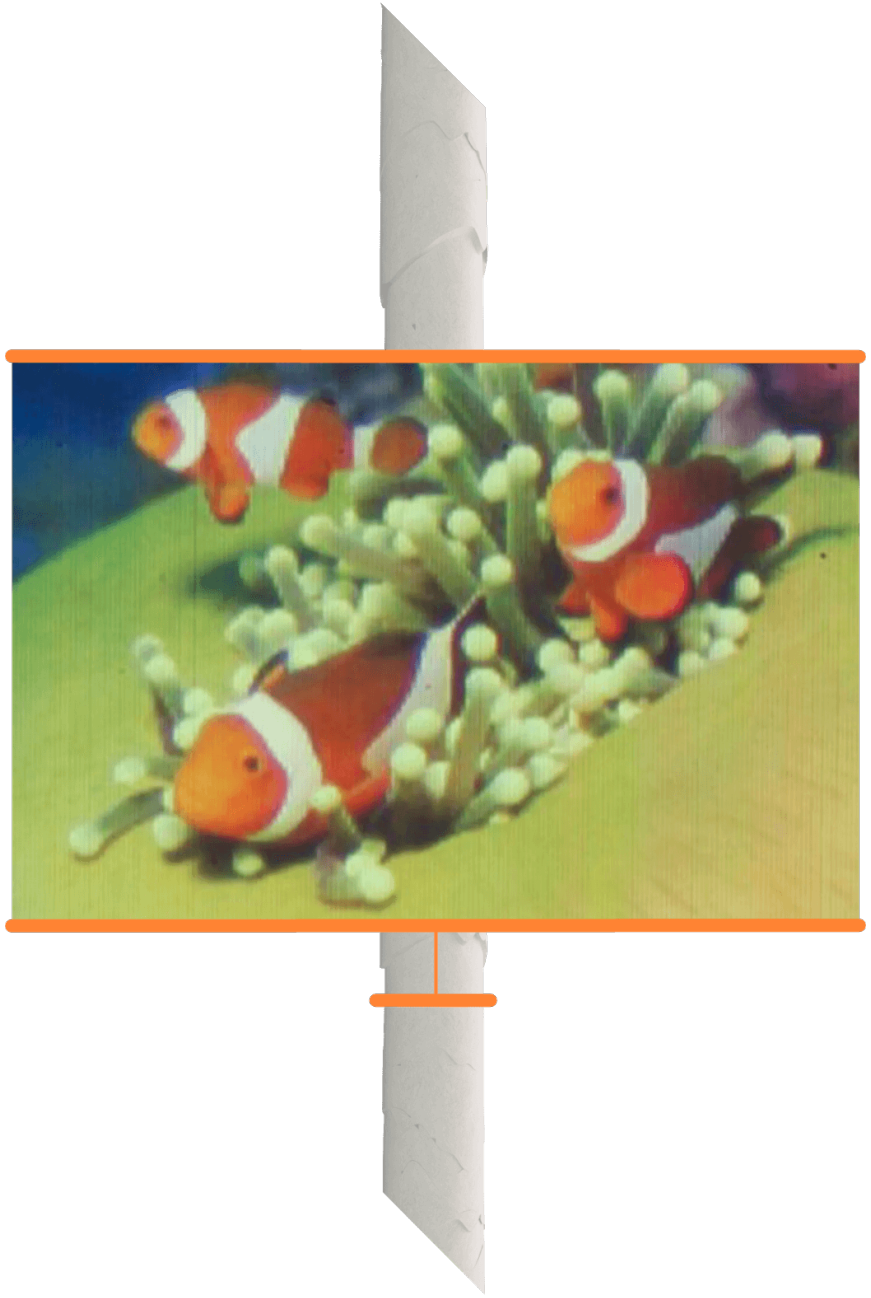
energy directly focused inside liquid



Uses MEMS-based micro-fabricated printhead technology

https://www.linkedin.com/posts/scrona_standard-inkjet-activates-a-pushing-force-activity-7115717620728819712-fsJK/

Scrona holds the world record for the smallest ever printed color photo. This image fits on the cross section of a strain of human hair.



Remember, Feynman's challenge of writing small!

https://www.scrona.com/

Printing functional materials

- **Thermochromic Inks:** These are temperature-sensitive inks that change color when the ambient temperature increases beyond a pre-designated value. They come in many colors like shades of neon, blue, purple, etc. Common applications include labels, print advertising, fabrics, biomarkers, and sensors.
- **Photochromic Inks:** These inks temporarily change color when exposed to UV light. Similar to thermochromic inks, these photochromic inks also come in several colors. They can be seen in light-sensitive eyewear solutions, body patches to detect exposure to sunlight, and clothing.
- **Hydrochromic Inks:** These inks change color when they interact with or get immersed in water. Typical applications include packaging solutions, moisture indicators, decorative umbrellas, and clothing.

https://www.melrosesystems.com/blog/all-about-functional-inks/
https://www.boydcorp.com/blog/fundamentals-functional-inks-part-1.html
https://www.boydcorp.com/blog/fundamentals-functional-inks-part-2.html

Micro Thermal Inkjet for Fuel Injection

- https://microsys.ust.hk/abstract/inkjet_fuel.htm

Thank You