Organic Batteries on Chip

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Broad Context

- There is a pent-up demand for safe and non-toxic batteries with immediately impact on the modern life, including applications in implantable medical devices, wireless communication devices, wearable's devices, digestible electronic pills, quantum computers and microelectronics system-on-chip.
- Lithium based batteries are technologically established, but they show serious chemical safety issues, associated with the use of their toxic chemical components.
- Organic redox-active compounds, such as quinones derivatives, can be composed of entirely by Earth-abundant elements, sustainable, nontoxic, nonflammable, and safe for use in microelectronics and medical microdevices.

Motivation

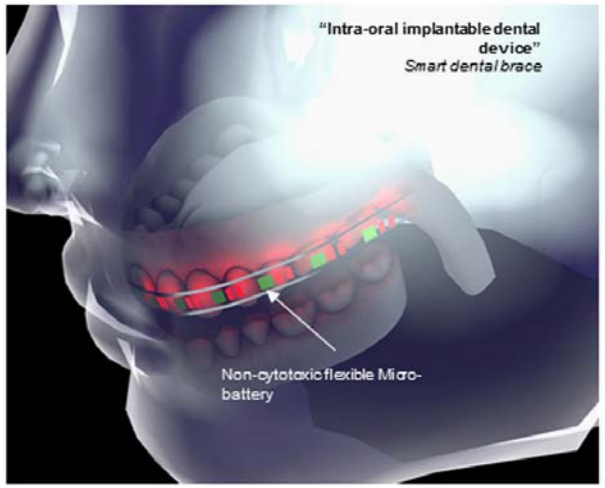
npj | Flexible Electronics

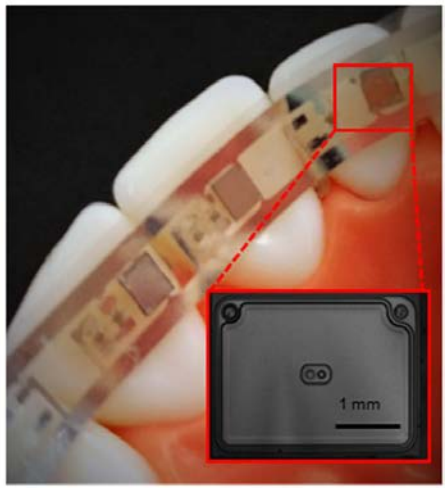
www.nature.com/npjflexelectron

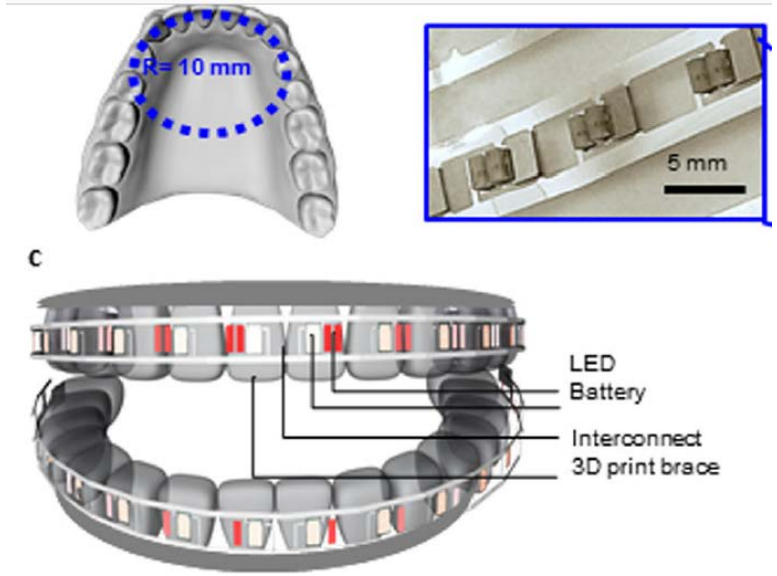
ARTICLE OPEN

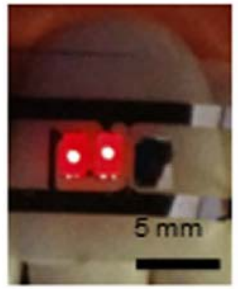
Flexible and biocompatible high-performance solid-state micro-battery for implantable orthodontic system

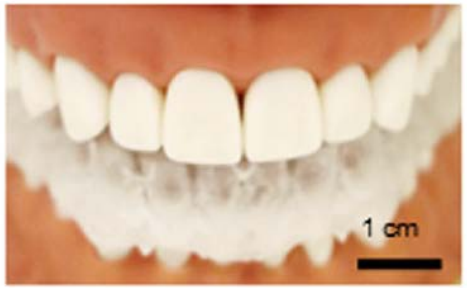
Arwa T. Kutbee[1], Rabab R. Bahabry[1], Kholod O. Alamoudi[2], Mohamed T. Ghoneim[3], Marlon D. Cordero[4], Amani S. Almuslem[3], Abdurrahman Gumus[3], Elhadj M. Diallo[5], Joanna M. Nassar[3], Aftab M. Hussain[3], Niveen M. Khashab[2] and Muhammad M. Hussain[3]











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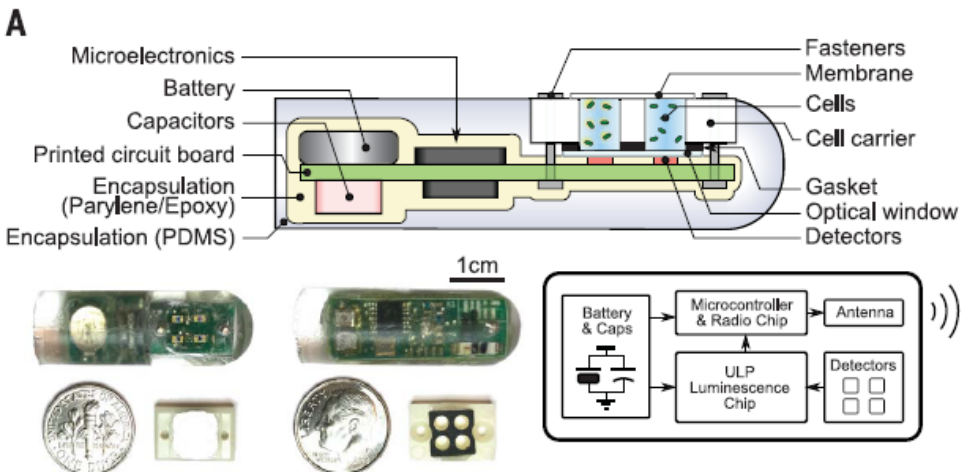
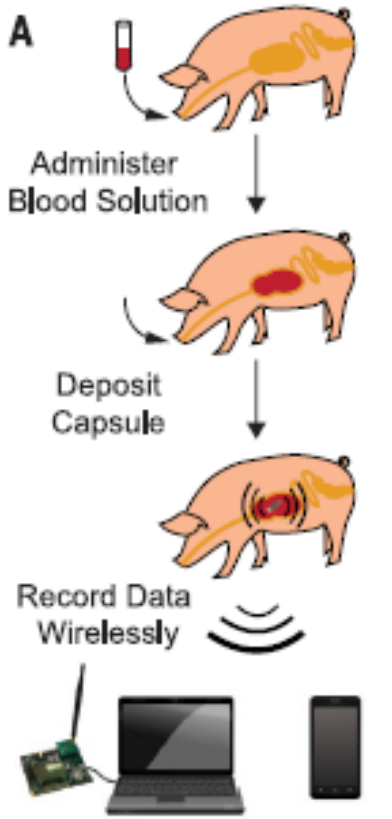
SYNTHETIC BIOLOGY

An ingestible bacterial-electronic system to monitor gastrointestinal health

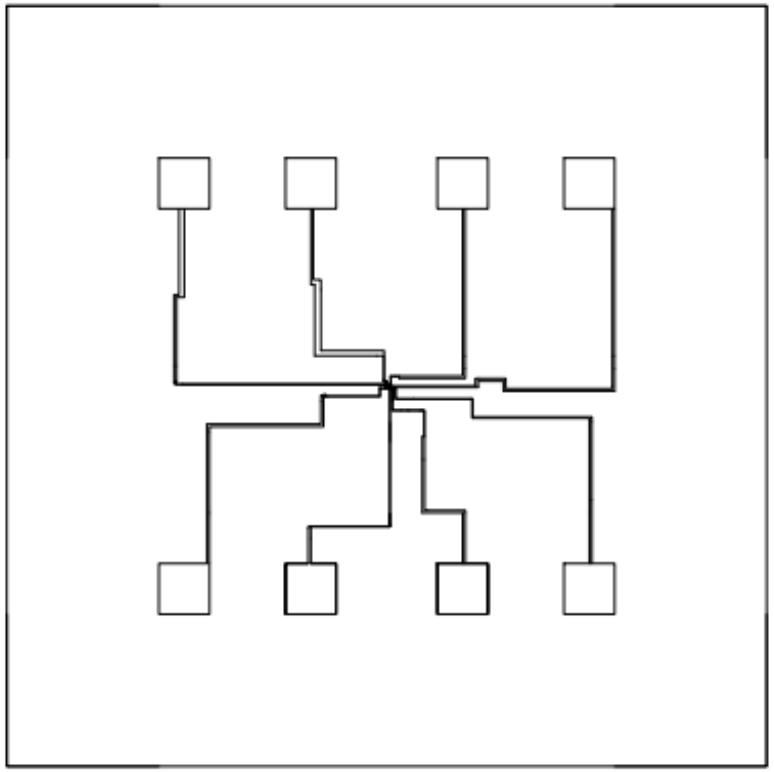
Mark Mimee,[1,2]* Phillip Nadeau,[3]*† Alison Hayward,[4,5] Sean Carim,[2] Sarah Flanagan,[3] Logan Jerger,[2,6,7] Joy Collins,[5] Shane McDonnell,[5] Richard Swartwout,[3] Robert J. Citorik,[1,2] Vladimir Bulović,[3] Robert Langer,[5,8] Giovanni Traverso,[5,8,9] Anantha P. Chandrakasan,[3]‡ Timothy K. Lu[2,3,10]‡

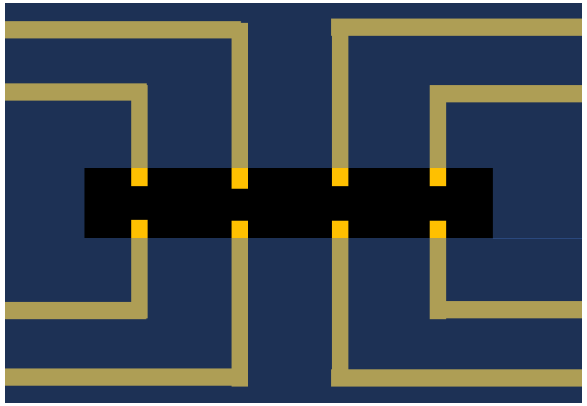




Objective

- Design and Fabricate Micro- and Nano Patterned Electrodes to Research Batteries on Chip Using Organic Electrolytes

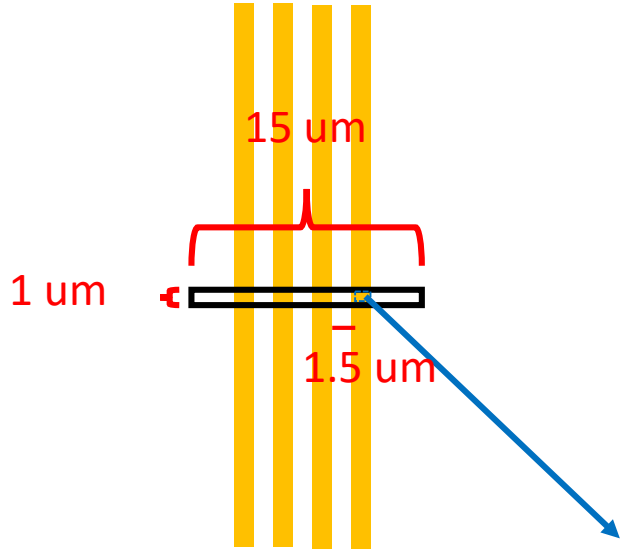




Si/SiO_2 wafer

Au

Insulator layer



Exposed area (electrode):
1 um x 1 um = 1 um^2

Nanofabrication Process Flow

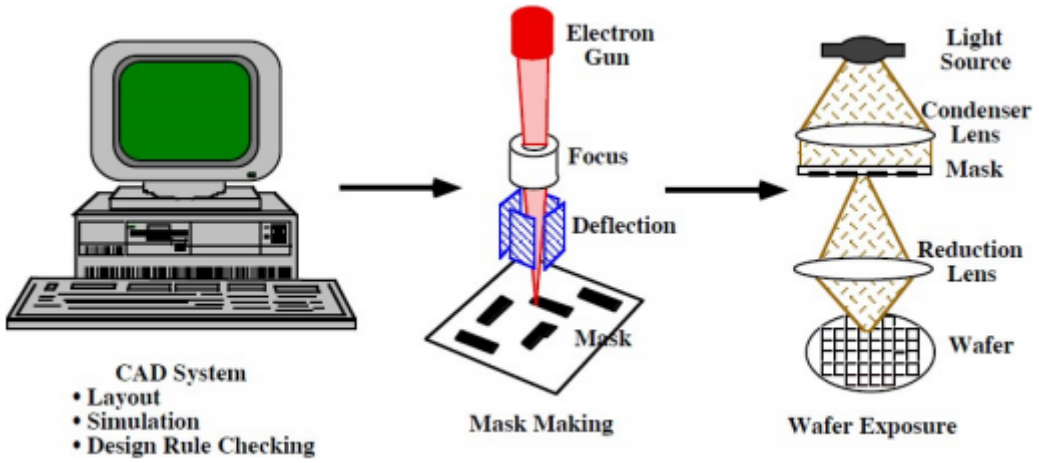
Design

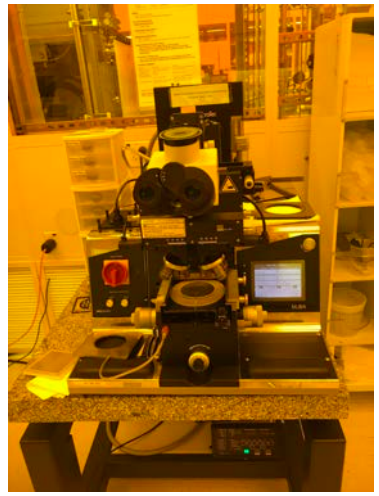
Solvent Clean

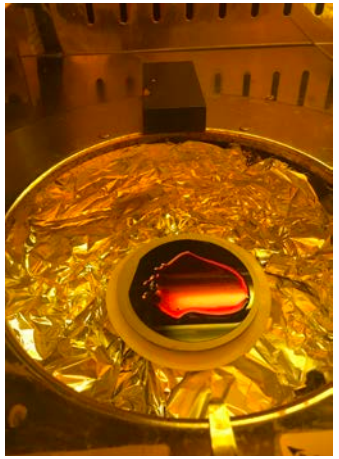
Photoresist

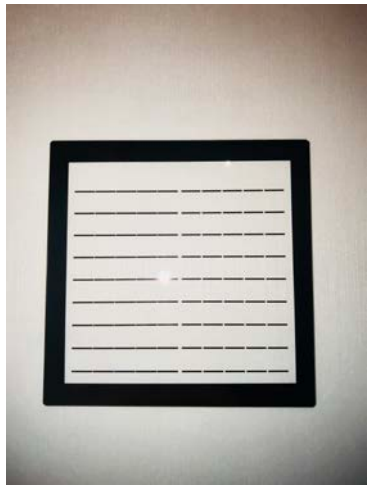
Soft Bake

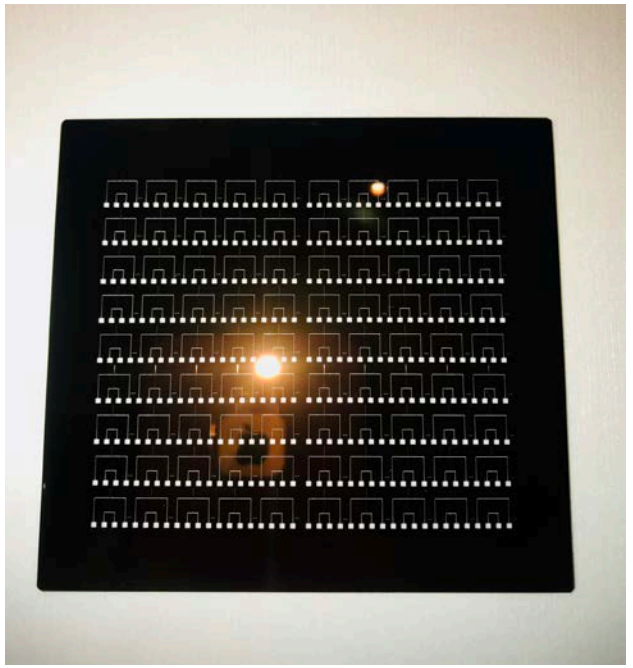
Expose MJB4





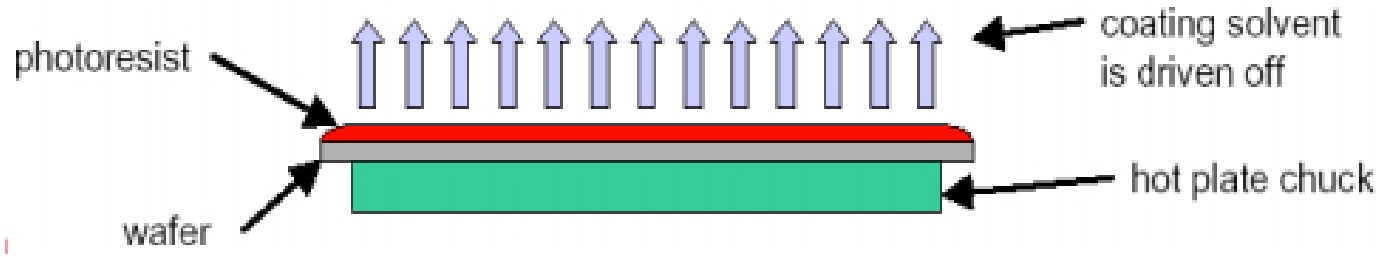


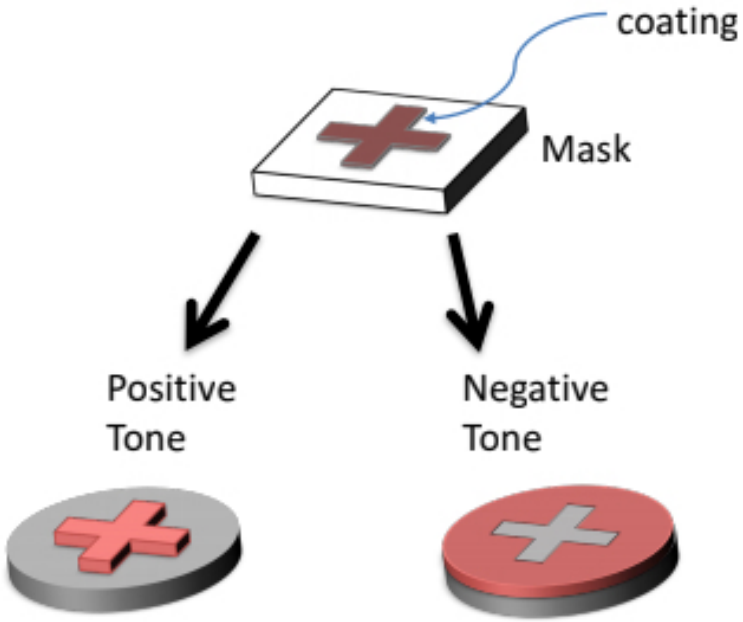


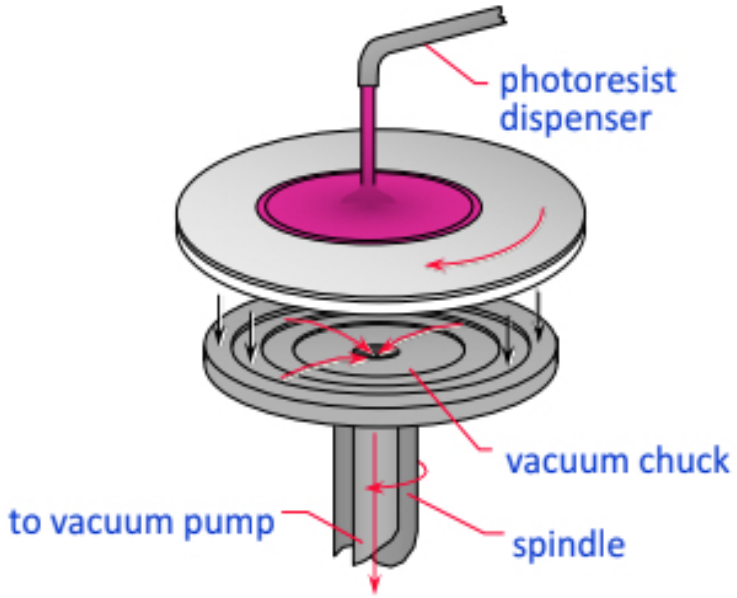


Evaporate Metal → Lift-Off → Insulator Layer → Dice Wafer

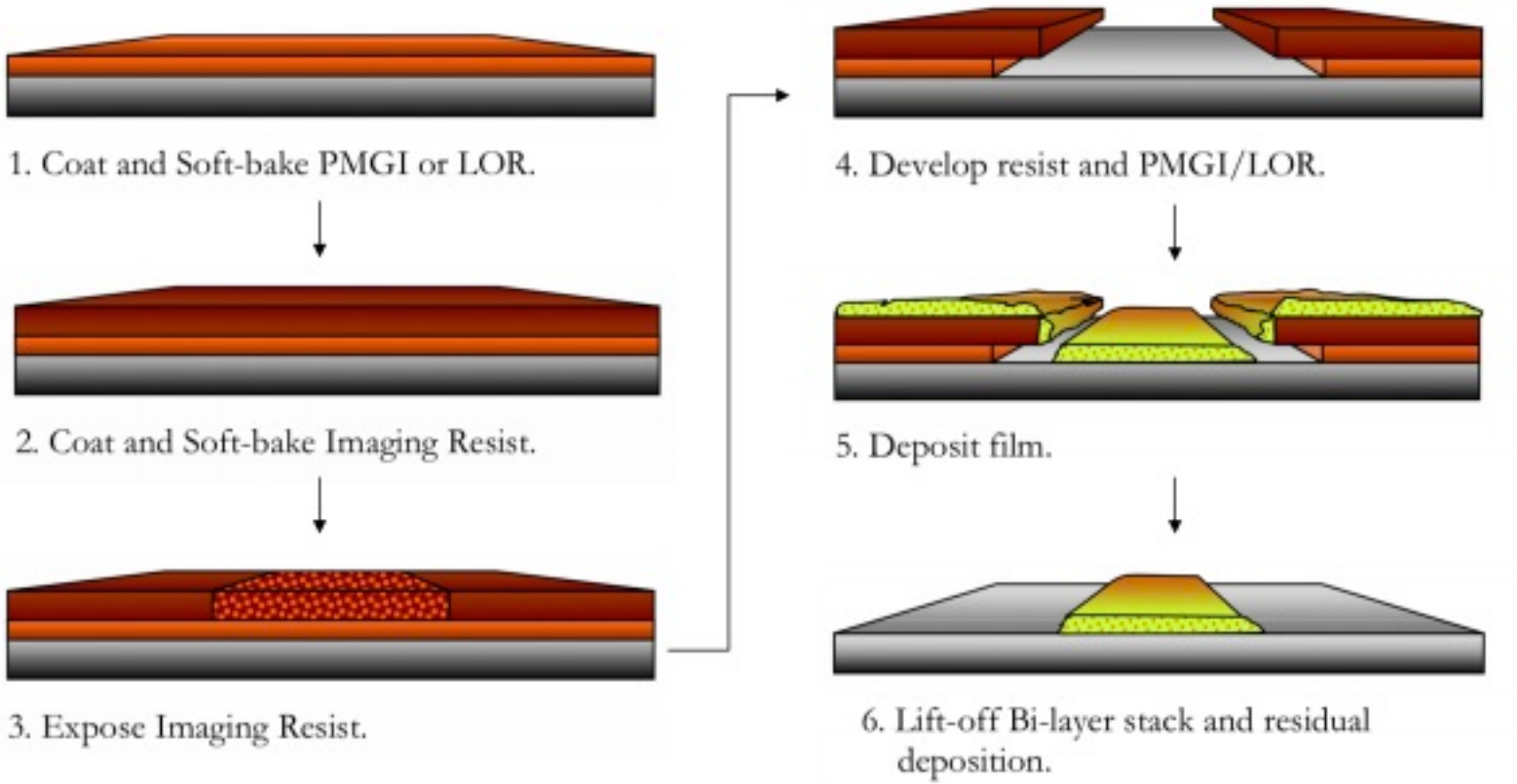
LOR3A and Shipley 1818 Bi-Layer Photoresist







Exposure Tool and Metal Deposition



Expose MJB4

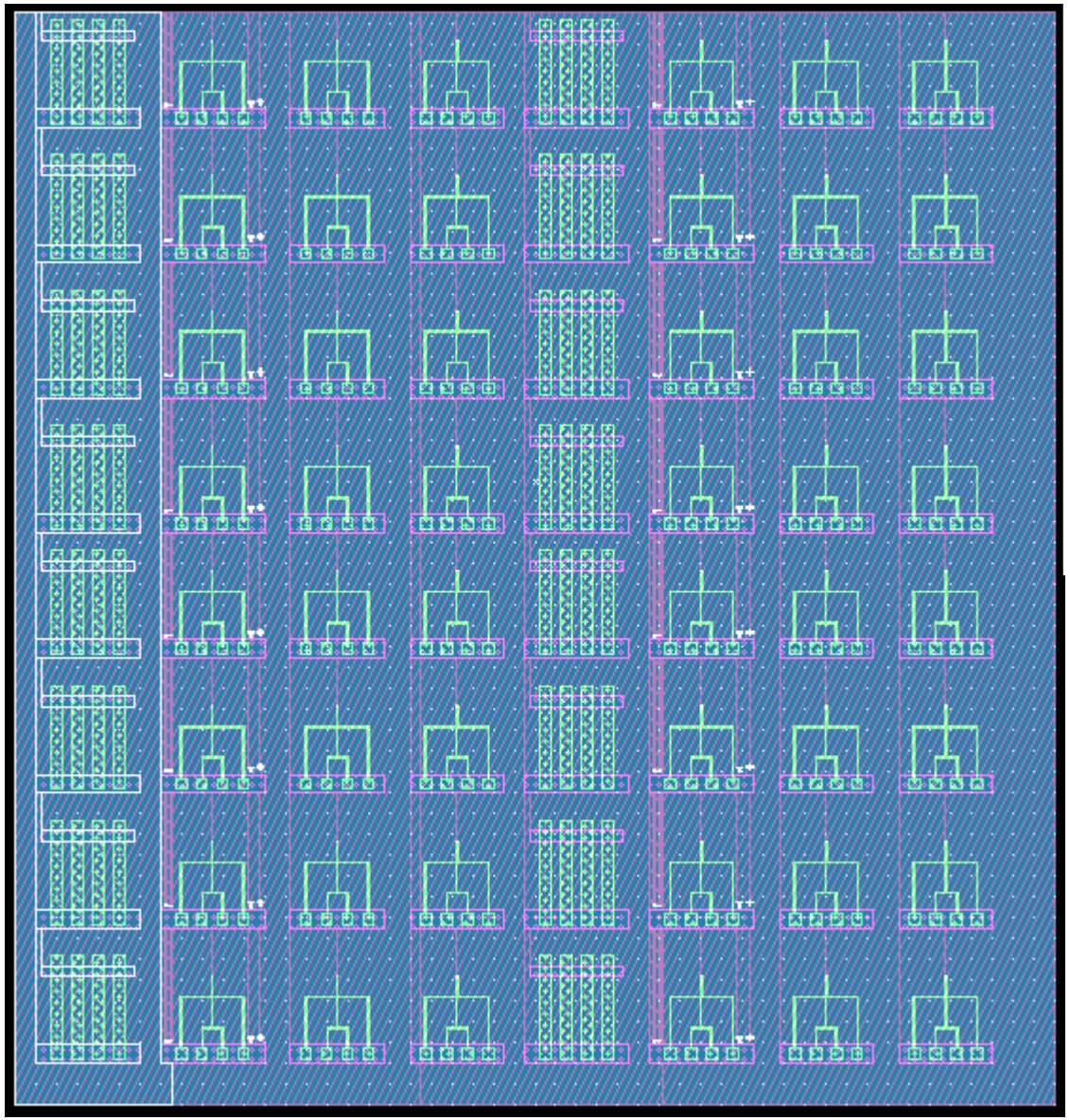
Developer MF-319

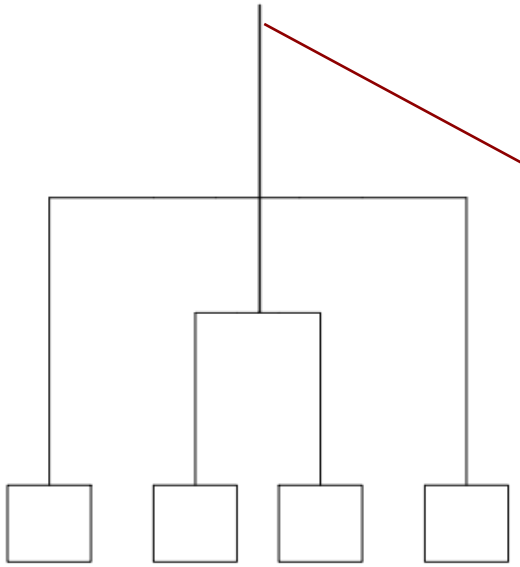
Metal Deposition

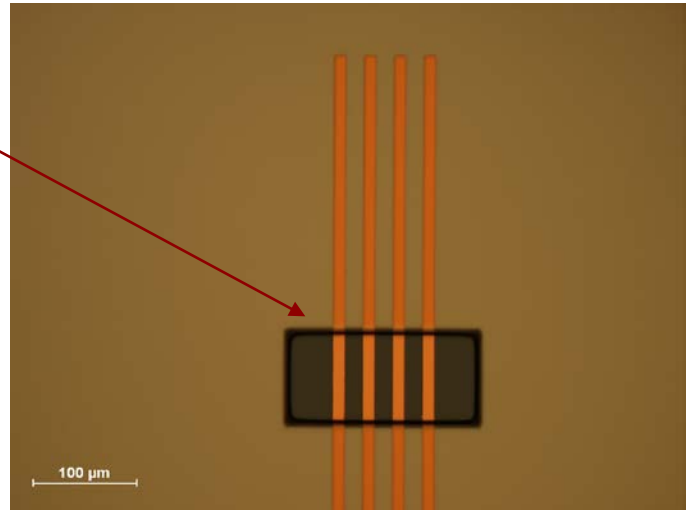
Lift-Off w/ Remover PG

Solvent Clean

Software Design via AutoCad

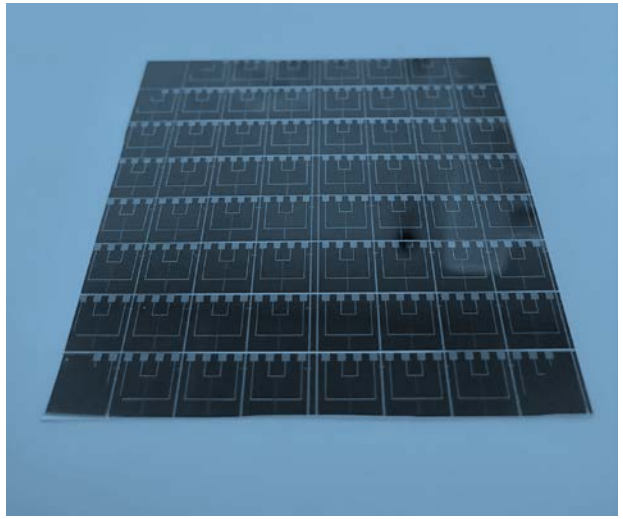


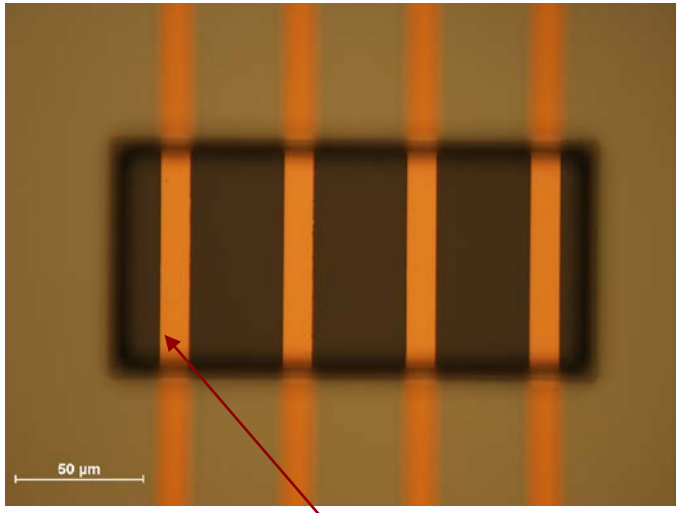


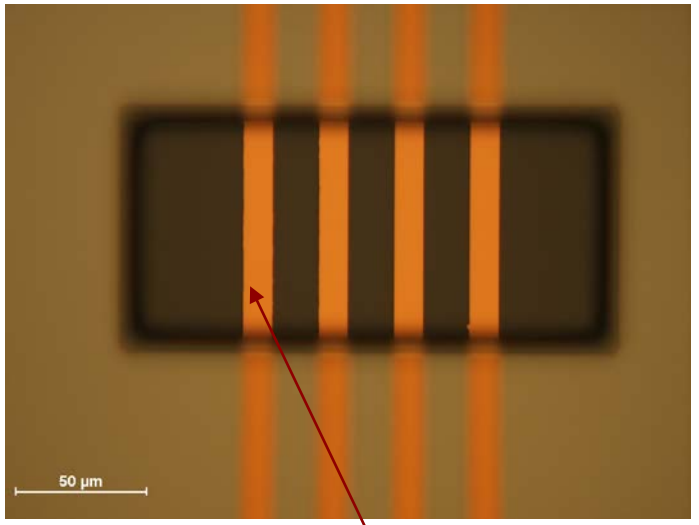


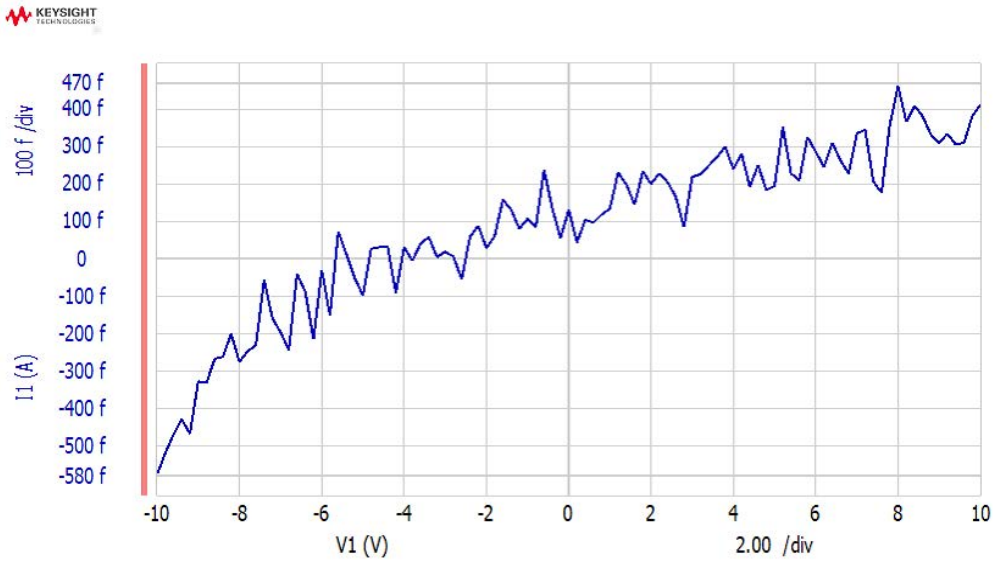
	Electrode width	Distance between the electrodes (gap)
1	10 um x 10 um	20 um
2	100 µm x 100 µm	200 µm
3	1 µm x 1 µm	2 µm
4	500 nm x 500 nm	1 µm
5	50 nm x 50 nm	100 nm
6	10 nm x 10 nm	20 nm

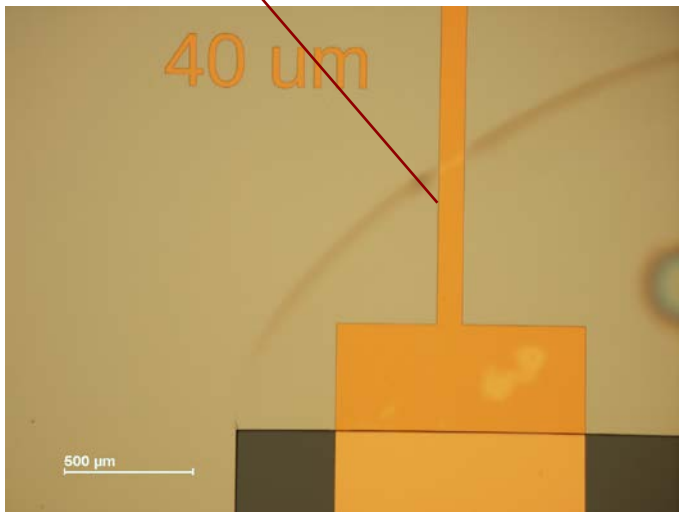
Results

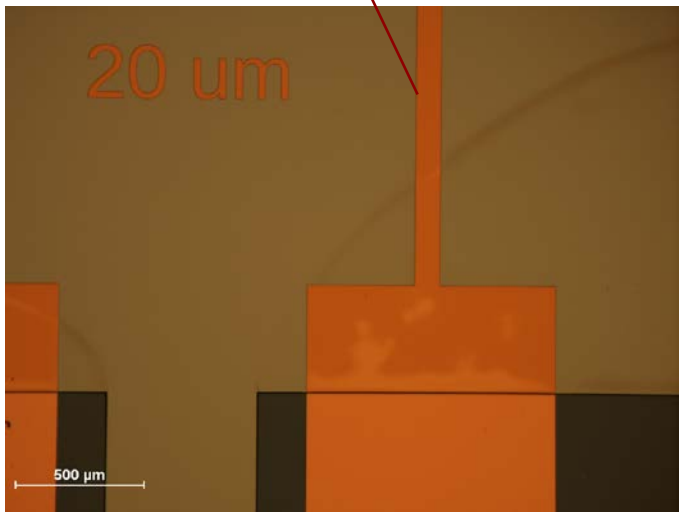



50 µm


50 µm

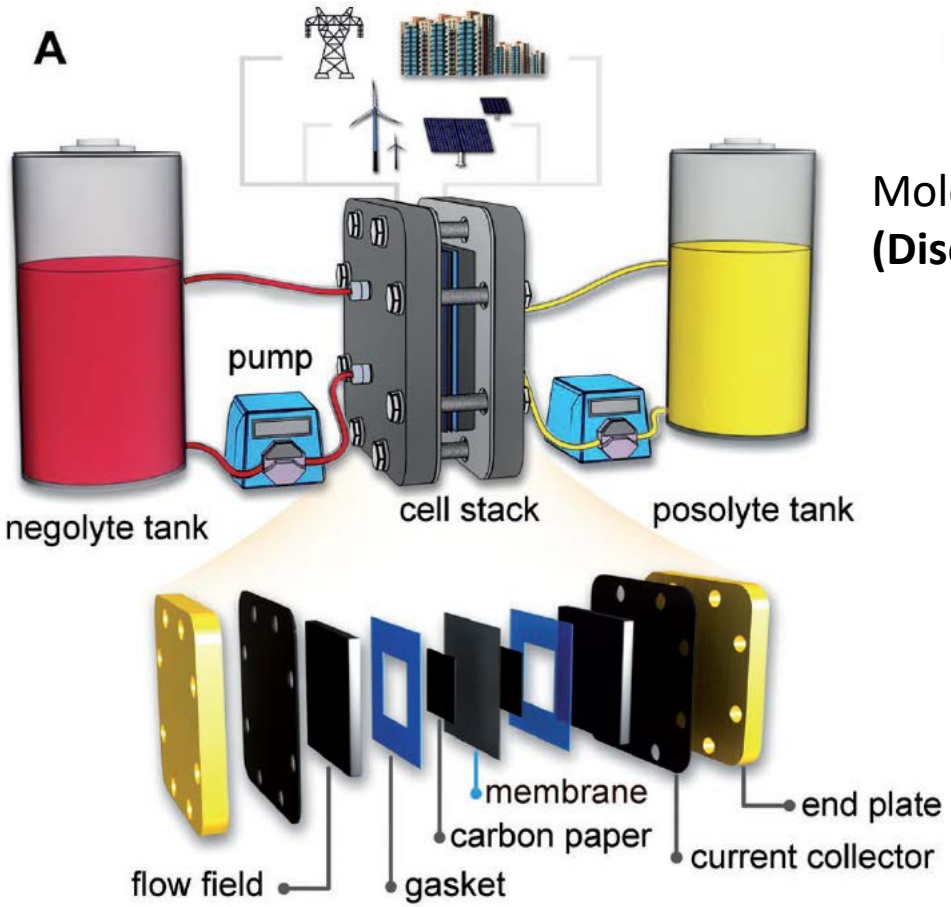

KEYSIGHT
TECHNOLOGIES
470 f
400 f
300 f
200 f
100 f
0
-100 f
-200 f
-300 f
-400 f
-500 f
-580 f
100 f /div
I1 (A)
-10
-8
-6
-4
-2
0
2
4
6
8
10
V1 (V)
2.00 /div


40 um
500 µm

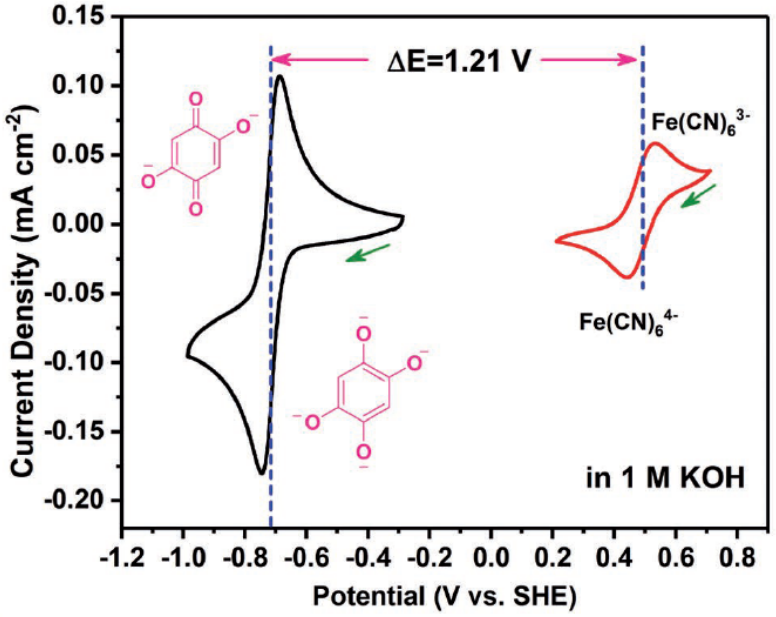

20 um
500 µm

Electrochemistry

Molecule is oxidized
(Discharging)



Molecule is reduced
(Discharging)



Discharging: molecule will be oxidized molecule will be reduced

References and Acknowledgments

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