

Perspective: Way of Sustainable Manufacturing for Disposable Quantum Spin Biosensors and Sticker-Like 2-Qubit Quantum Computers

Rajasekaran Beniel Jones and Gyoujin Cho

Institute of Quantum Biophysics (IQB)
Sungkyunkwan University



Institute of Quantum Biophysics (IQB)



IQB VISION

Institute of Quantum Biophysics



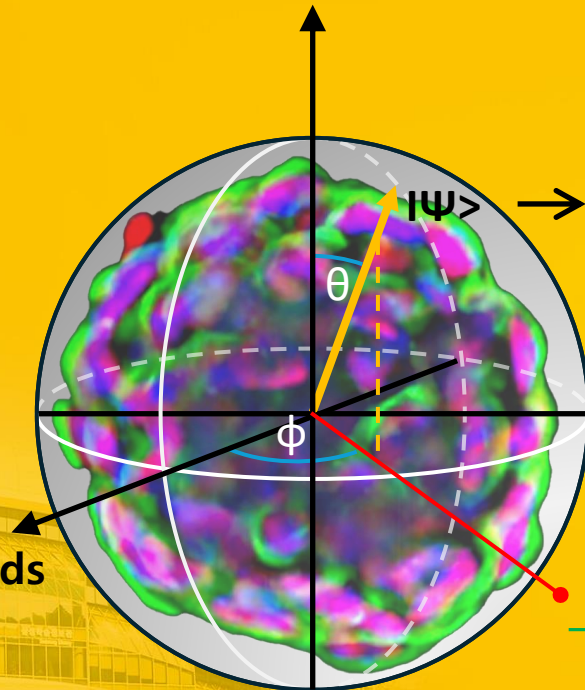
| Incurable diseases >

| World's first personalized quantum healthcare>

- Q-PoCT of acoustic imager, NMR, and MRI
- Q electron tunneling-based rejuvenation of dysfunctional mitochondria
- Q-sensor integrated multi-organ monitoring platform
- Q computing for multi-omics

Multi-omics

Multi-organoids

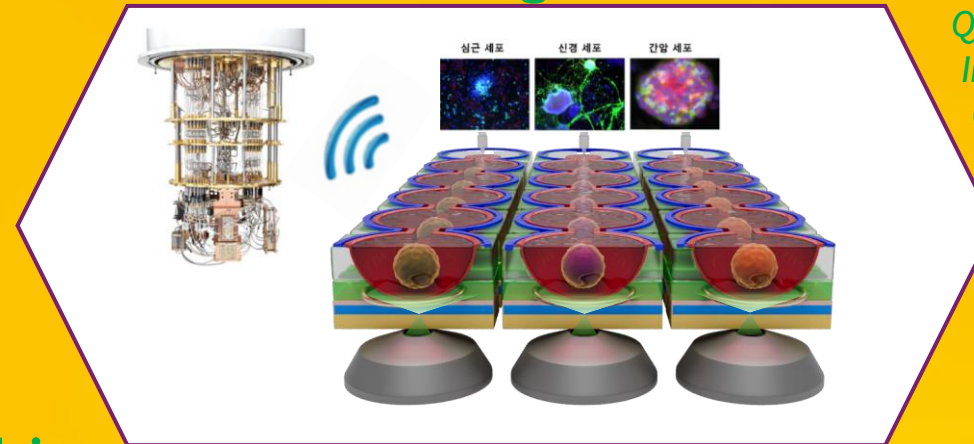


$$\frac{|Seed fund > + |IQB fund >}{\sqrt{2}}$$

| Quantum spin, entanglement, and tunnelling >

IQB: Aligning in quantum biotechnology (QBT)

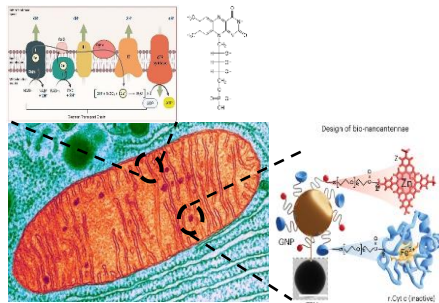
Quantum Computing for Omics of Human Axis Organoids



Personalized Rx:
Quantum sensor
Integrated
Organs on
System
(qSOS-Rx)

Basic Research in Quantum Electron Tunnelling in Mitochondria

Flavin in Mitochondria



Rejuvenate
dysfunctional
mitochondria

Preventive QD for
gene mutation

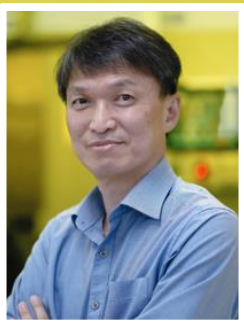
Quantum Bio-Sensor
Integrated Human Axis
Organoid System

Q-acoustic imager, NMR & MRI for Q-PoCT



System Design for Q
PoCT of acoustic Imager,
NMR & MRI

Large-scale
Advanced
Manufacturing
Platform (LAMP)
for Q-acoustic imager,
NMR & MRI



Cho, Gyoujin | Large-scale Additive Manufacturing Platform (LAMP)

👤 Professor, Vice Director of Institute of Quantum Biophysics and Director of Research Engineering Center for Flexible Computer

📖 Biophysics

☎ 031-299-4793

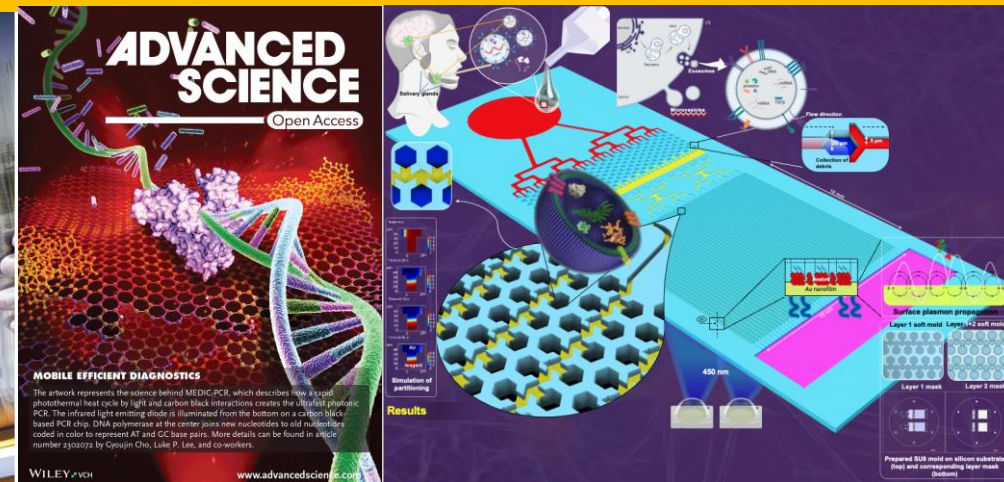
Current Research

Developing nucleic acid-based 3-U (ultra-fast, ultra-low cost, ultra-sensitive) diagnostic technology by:

- utilizing surface plasmonic resonance and q-spin to attain ultra-sensitive detection
- roll-to-roll gravure integrated imprinter for high-throughput sustainable fabrication.

Prospective Research

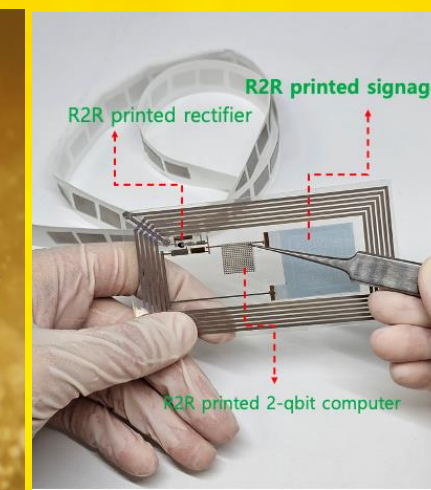
- Optimization of R2R gravure integrated imprinter as LAMP to manufacture a limitless number of d-PCR and Q-spin sensors to monitor the health of organisms via exosome assay.
- Development of a high-throughput, all-automatic, multi-organoid monitoring Q-sensor system for drug screening.



Disposable plasmonic digital PCR



Disposable Q-spin sensor



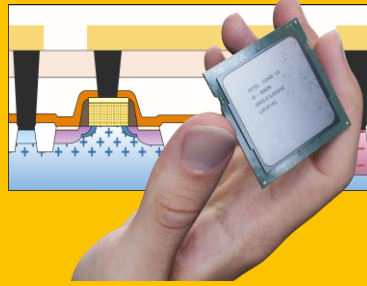
Disposable RF 2-qubit computer

Why do we care about sustainable manufacturing?

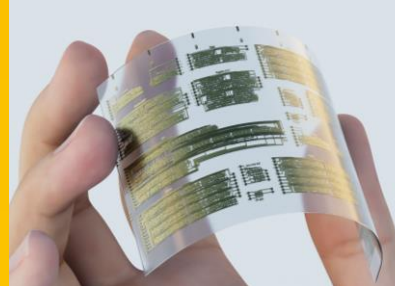
Vacuum tube
based computer



CMOS based
rigid computer

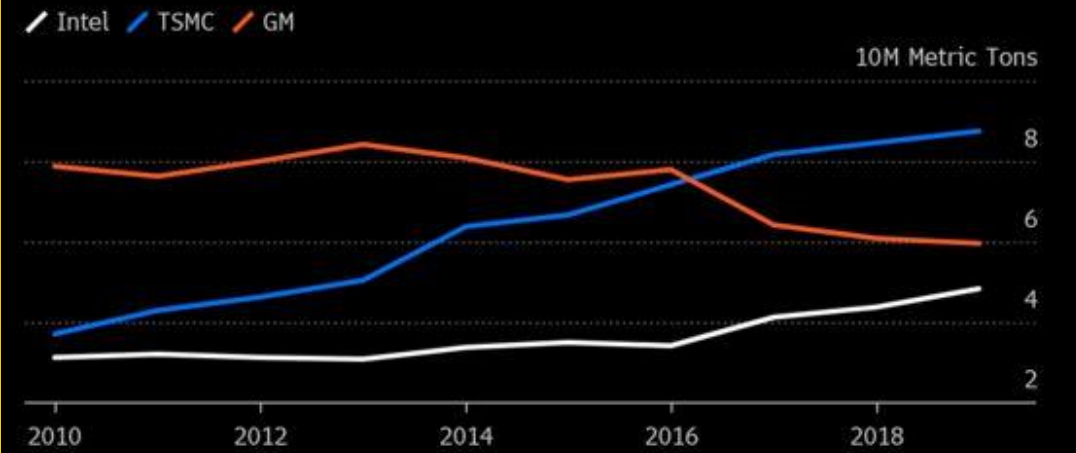


Printed CMOS based
flexible computer



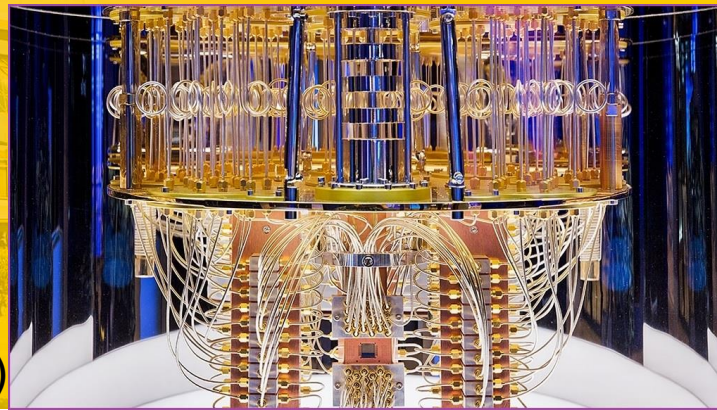
<i>Fabrication Process</i>	Glass tube seal/gettering	Photolithograph/vacuum	R2R gravure printing
<i>Power consumption</i>	> 100 kWh per 1 inch	10,000-50,000 kWh per 1 inch	<0.9 kWh per 1 inch
<i>By product</i>	~ 10 kg (per 1 inch) of waste-water/solid	~ 10 kg (per 1 inch) of waste-water/solid	Rear zero (per 1 inch) of water/solid
<i>Fabrication time</i>	~ 7 days	~ 7 days	< 1 hr
<i>Application</i>	Simple function computer	Smartphone with AI	Sticker label for edge computing

Chip Producers Overtaking Automakers as Polluters The environmental cost of semiconductors is rising

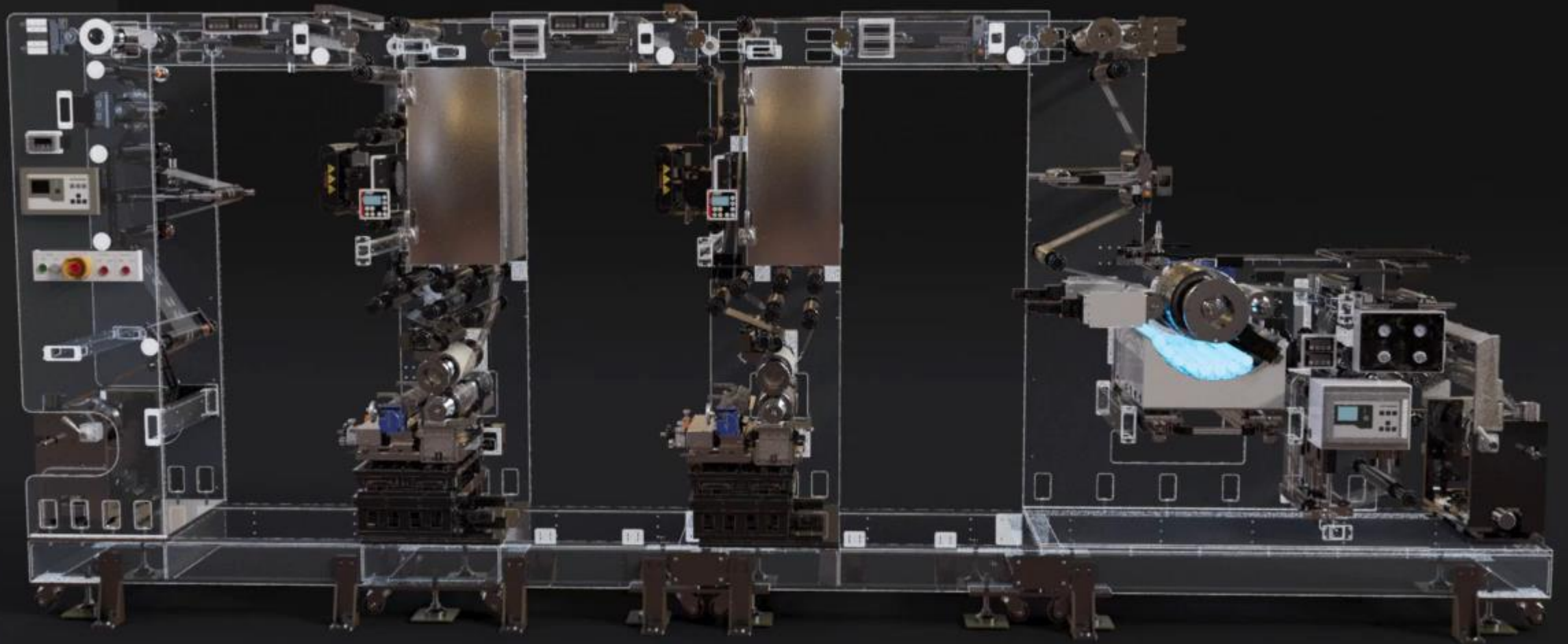


Source: Company disclosures
Note: Metric tons of green house gas emissions

Bloomberg



R2R Gravure Fabrication: Sustainable High-throughput Manufacturing



Disposable Quantum Spin Biosensors

Typical Instrumentation and setup of NV⁻ diamond based nanoscale NMR

Image taken from [NATURE PROTOCOLS](#)|VOL 14|SEPTEMBER 2019|2707–2747

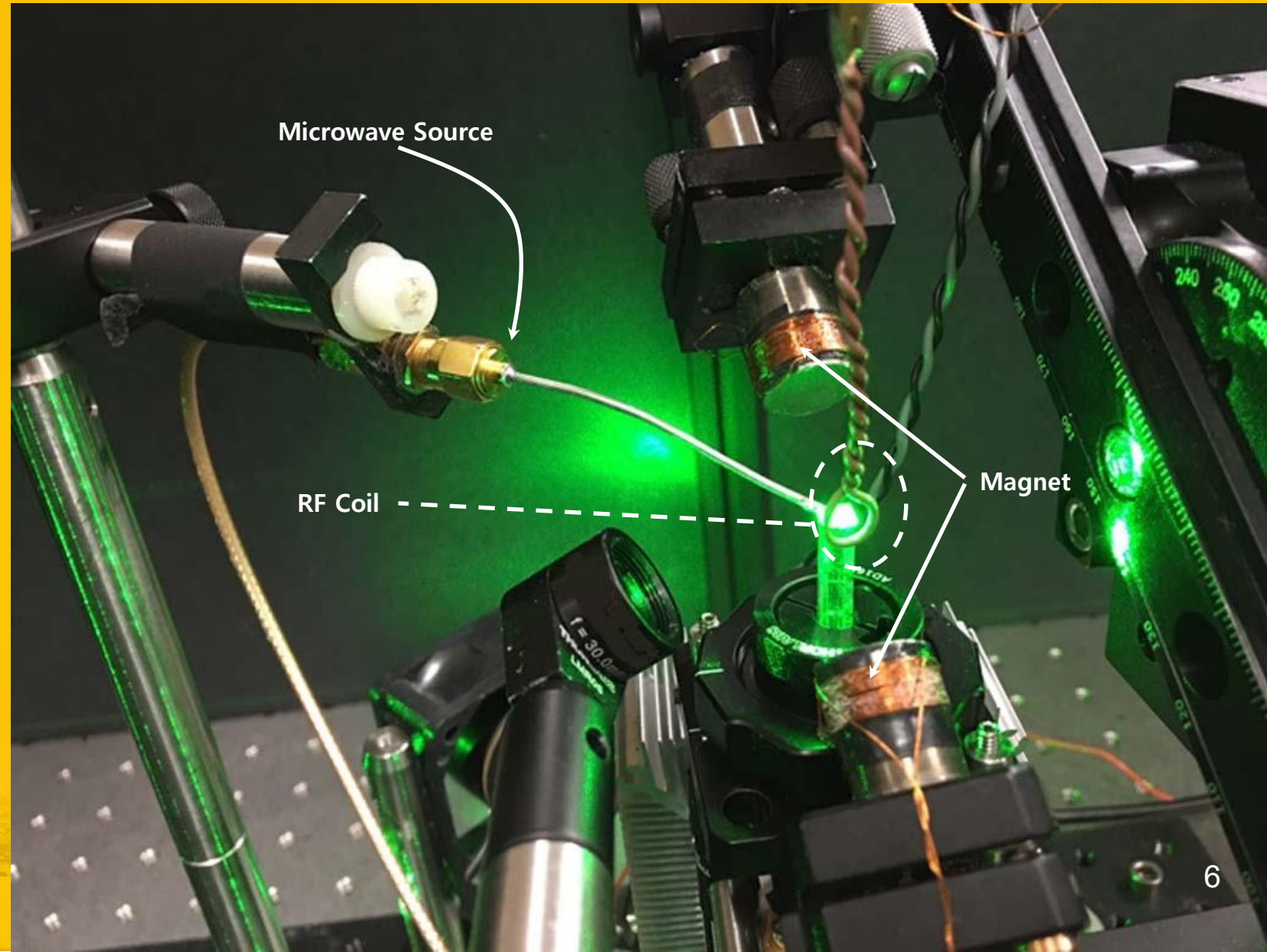
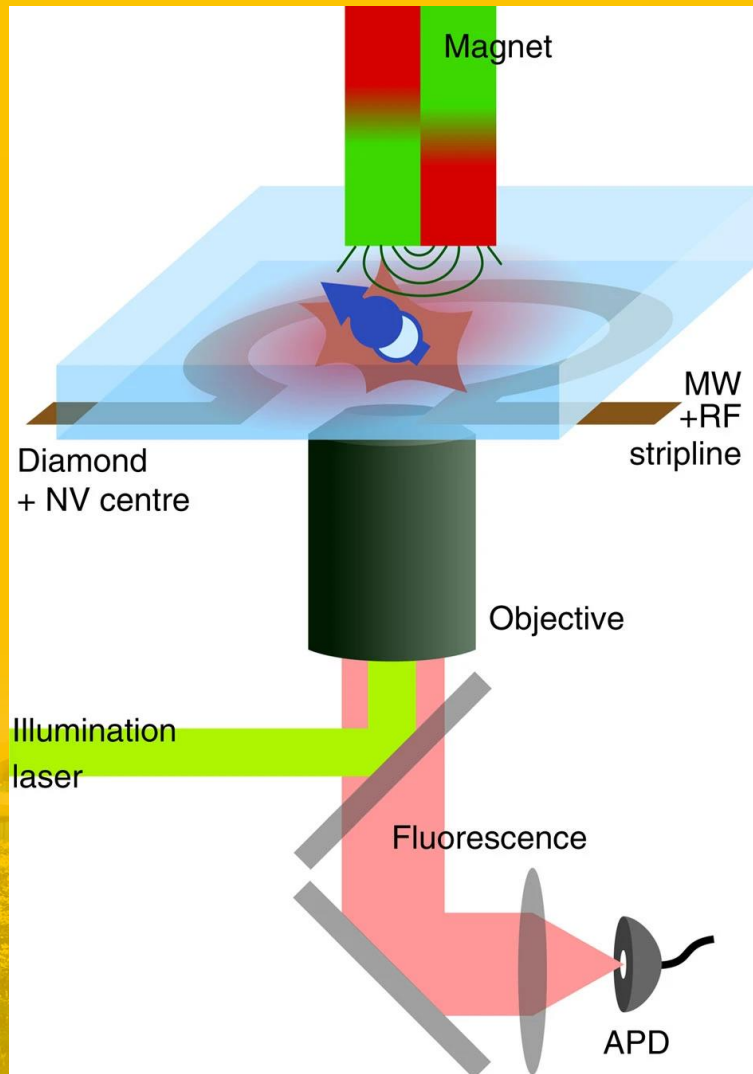
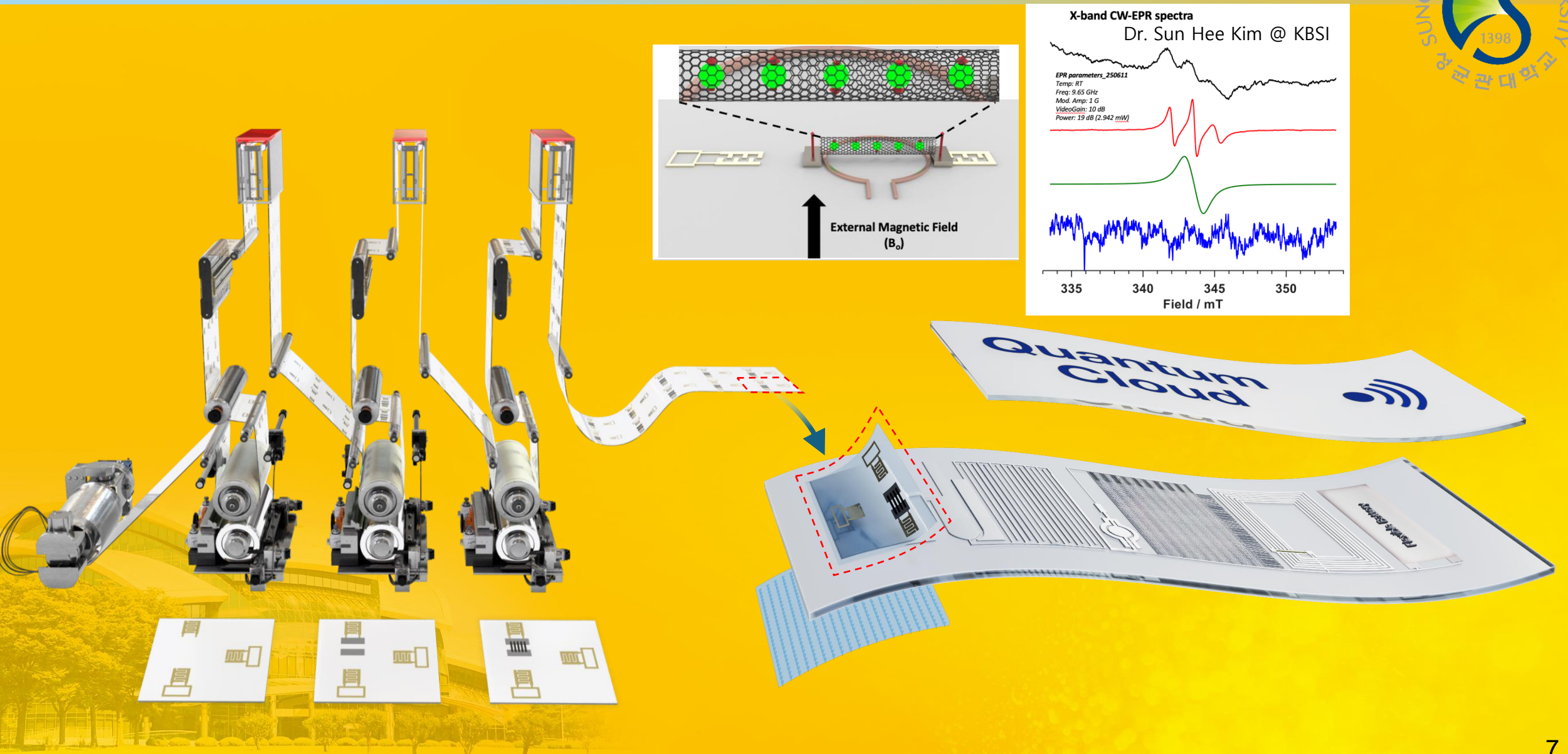


Image taken from [NATURE COMMUNICATIONS](#) | 7:1
2279 | DOI: 10.1038/ncomms12279

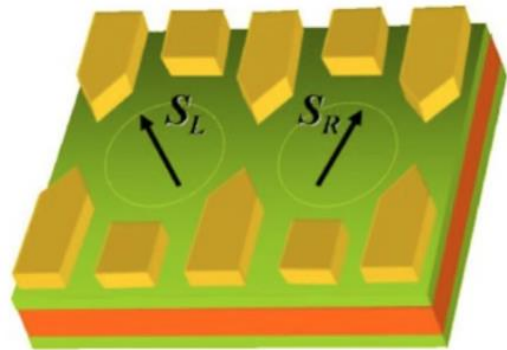
Disposable Quantum Spin Biosensors



Single Molecular Level Realtime Diagnosis

Sticker-Like 2-Qubit Computer

Quantum dot



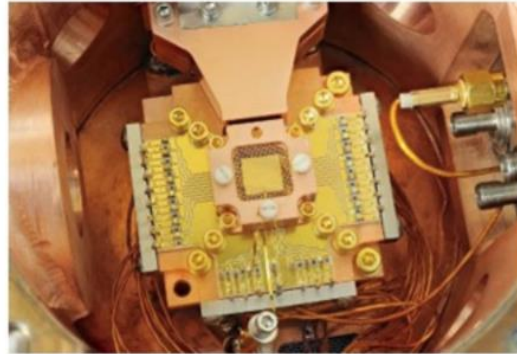
Spin Up - $|0\rangle$



Spin Down - $|1\rangle$



Trapped ion



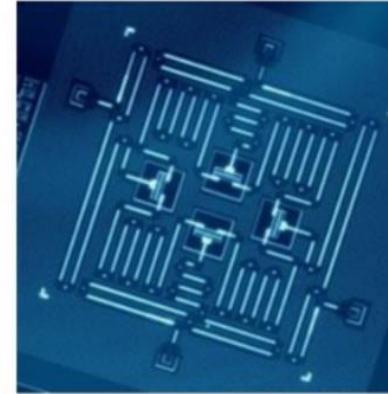
Spin Up - $|0\rangle$



Spin Down - $|1\rangle$



Superconducting transmon



0 Cooper pairs - $|0\rangle$

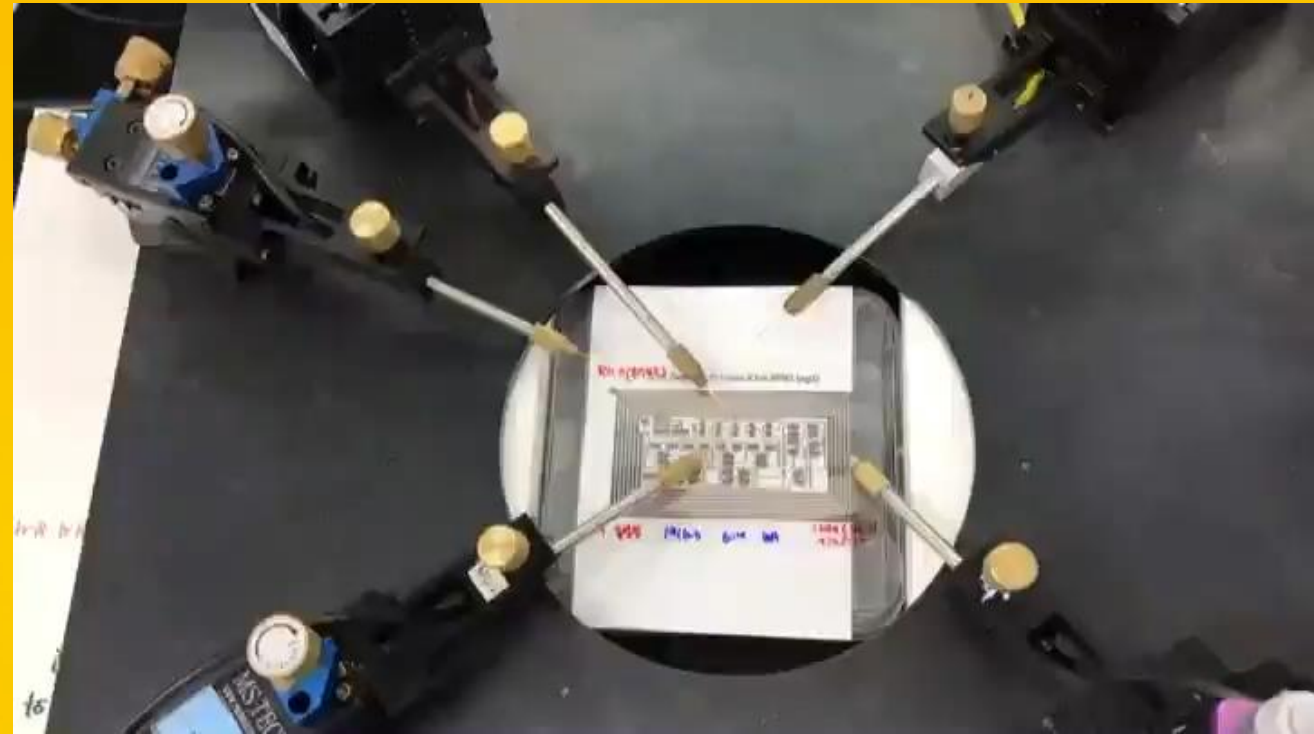
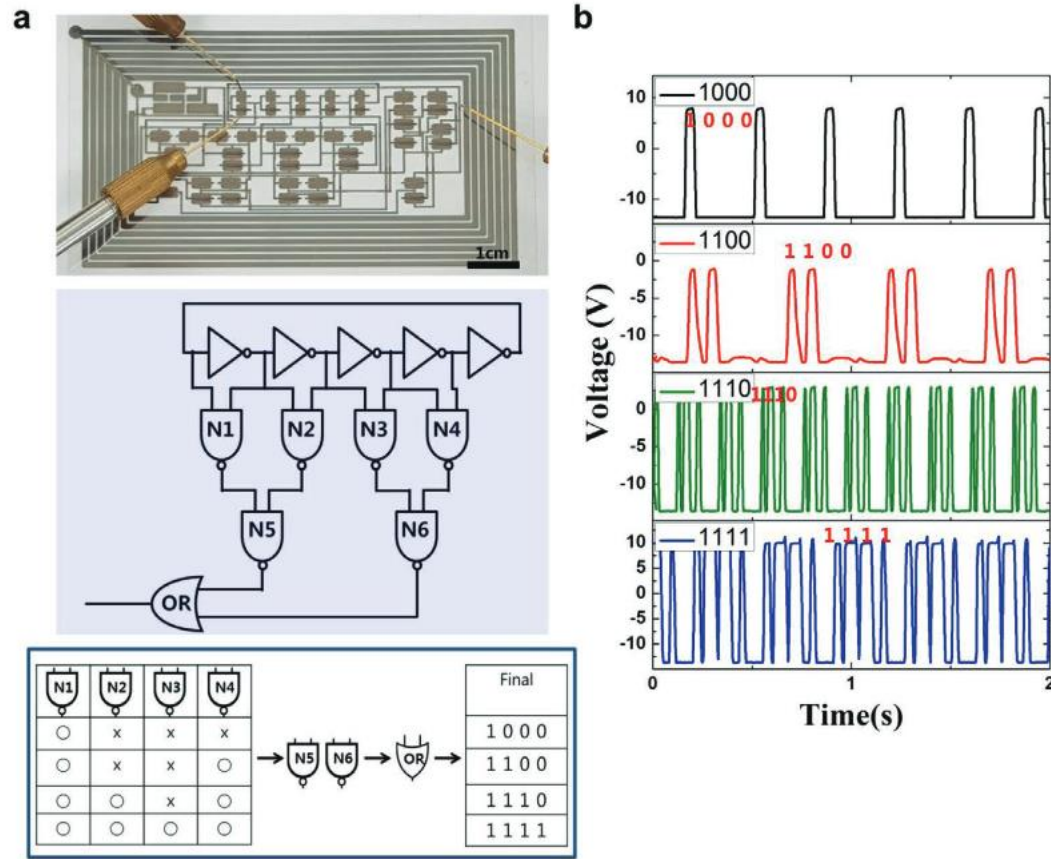
1 Cooper pair - $|1\rangle$



SpinQ Gemini
2-qubit Desktop NMR Quantum Computer

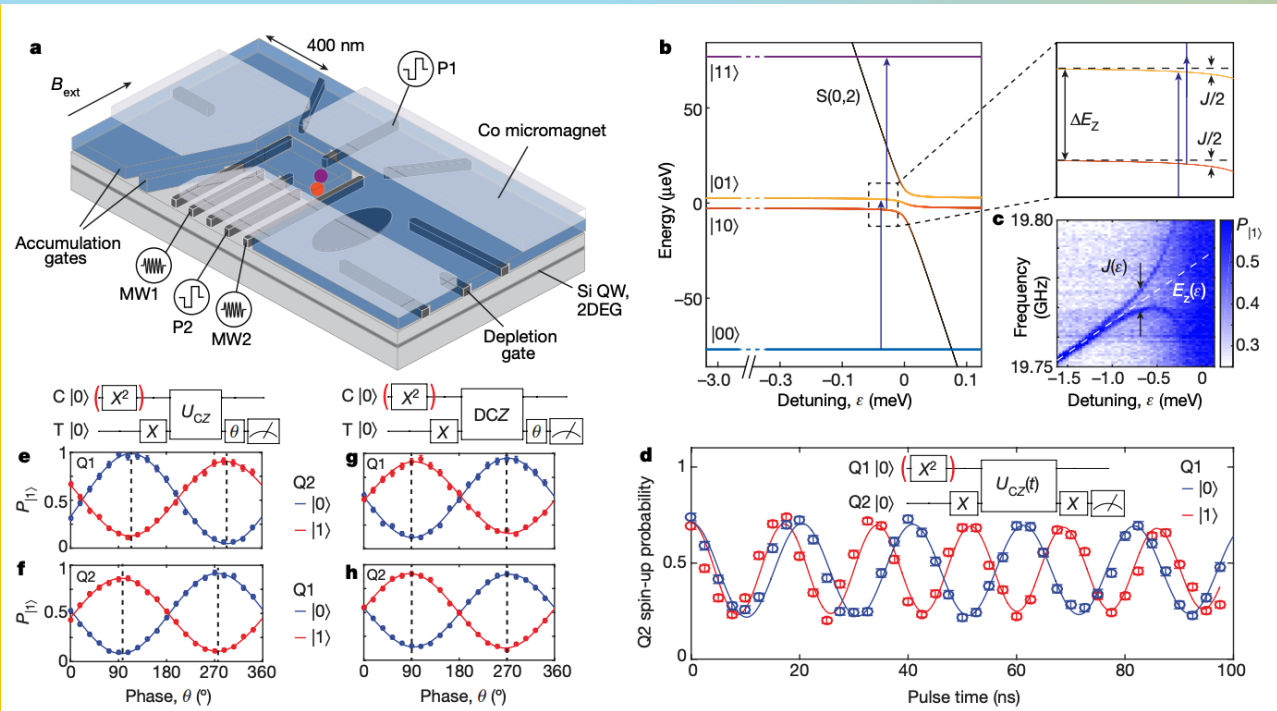


Sticker-Like 2-Qubit Computer



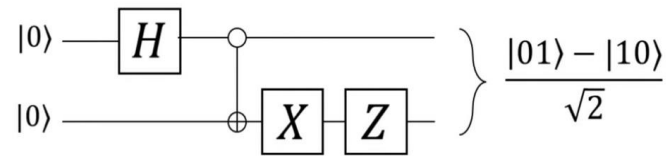
Adv. Electron. Mater. 2020, 6, 2000770

Sticker-Like 2-Qubit Computer

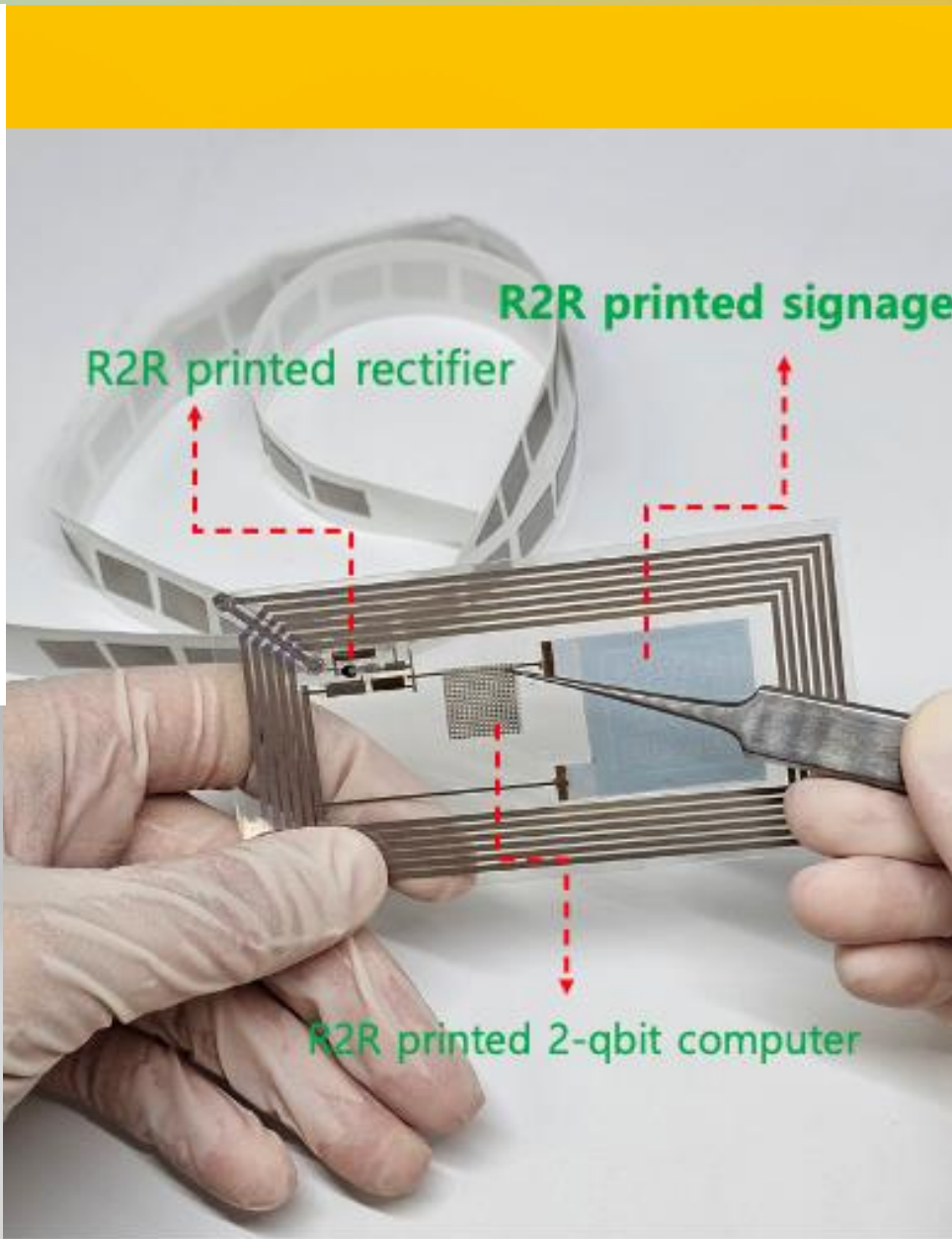


29 MARCH 2018 | VOL 555 | NATURE | 633

Bell State Preparation



$$(I \otimes Z)|\Psi^+\rangle = \frac{|01\rangle - |10\rangle}{\sqrt{2}} \equiv |\Psi^-\rangle$$



IQB's Leadership



Annual International Conference “WISDOM” since 2023

**WISDOM:
QUANTUM LIFE
SCIENCE FOR
MEDICINE**

World Innovation Summit for Dementia:
Opportunities and Challenges in Medicine

Venue
Auditorium, Natural Sciences Campus, Sungkyunkwan University, Suwon

Date
2023. 07. 06 (Thu) - 08 (Sat)

Prof. Ortwin Hess
Chair Professor of Quantum
Nanophotonics, Trinity College Dublin

Prof. Cees Dekker
Distinguished University Professor,
Delft University of Technology

Prof. Luke P. Lee
Director of IQB, SKKU ; Professor of
Medicine, Harvard Medical School

Prof. Taekjip Ha
Bloomberg Distinguished Professor,
Johns Hopkins University

성균관대학교
SUNGKYUNKWAN UNIVERSITY

Institute of Quantum Biophysics | 생명물리학과
Department of Biophysics

**WISDOM
SYMPOSIUM
2024** Quantum Perspectives in Biology
& Future Insights in Neuroscience

8th July, 2024 / 9:00 – 17:30
600th Anniversary Memorial Hall
Sungkyunkwan University, Seoul

Plenary Speakers

- YongKeun Park (KAIST)
- Tony Hu (Tulane Univ.)
- Inhee Mook-Jung (Seoul National Univ.)
- C. Justin Lee (IBS)

09:00-09:20 | Registration & Opening Remarks (Prof. Luke P. Lee)

09:20-10:10 | YongKeun Park (KAIST)
Holotomography and artificial intelligence: label-free 3D imaging, classification, and inference of live cells, tissues, and organisms

10:10-10:40 | Sung Sik Lee (ETH Zurich)
Optofluidics for Biology of Aging

10:40-10:50 | Short Coffee Break

10:50-11:40 | Tony Hu (Tulane University)
AI-based Omics Analysis Enabling Personalized Diagnosis

11:40-12:10 | Kyung-Duck Park (POSTECH)
Tip-enhanced nano-spectroscopy for investigating single molecules

12:10-13:00 | Lunch & Introduction of IQB results

13:00-13:50 | Inhee Mook-Jung (Seoul National University)
The current insights into Alzheimer's disease pathogenesis

13:50-14:20 | Jinsoo Seo (DGIIST)
Identifying presymptomatic cellular changes in neuronal cells with Alzheimer's disease-associated genetic factors using HiFi-Seq

14:20-14:50 | Kwang Min Kim (Gachon University)
Region-specific human in vitro brain tissue models for studying nerve regeneration in the central nervous system

14:50-15:10 | Coffee Break

15:10-16:00 | C. Justin Lee (IBS)
Amyloid-beta is an H2O2-decomposing peroxidase and a therapeutic target for Alzheimer's disease

16:00-16:30 | Seok-Cheol Hong (Korea University)
Exploring Physical Mechanism of Biological Phenomena: From Single-Molecule Insights into DNA Mechanics to Dynamic Outcomes of Rayleigh Particles & Live-Cell Cargo Transport

16:30-17:00 | Byoung Choul Kim (Incheon National University)
Unlocking the Mechanobiological Secrets of Amyloidosis Using Single-Molecule Force Probes

17:00-17:30 | Closing & Awards (Prof. Luke P. Lee)

Scan for WISDOM 2024 Link
(19th May ~ 9th July, 2024)
(Ft. 150,000 won, Students: 50,000 won)
Contact: jongchan@skku.edu

WISDOM Sept. 22nd.2025
Suwon Convention Center
Supported by 한국관광공사

Thank you

