# Molding Tomorrow: Innovating with the Materials of the Future

# Chris Blundell

Partner, Head of Global Technology, Media & Telecoms

Brunswick Group

MWC24

# Dr Zina Jarrahi Cinker

Director General, MATTER & Chief Creator

PUZZLE X

# MATTERVERSE

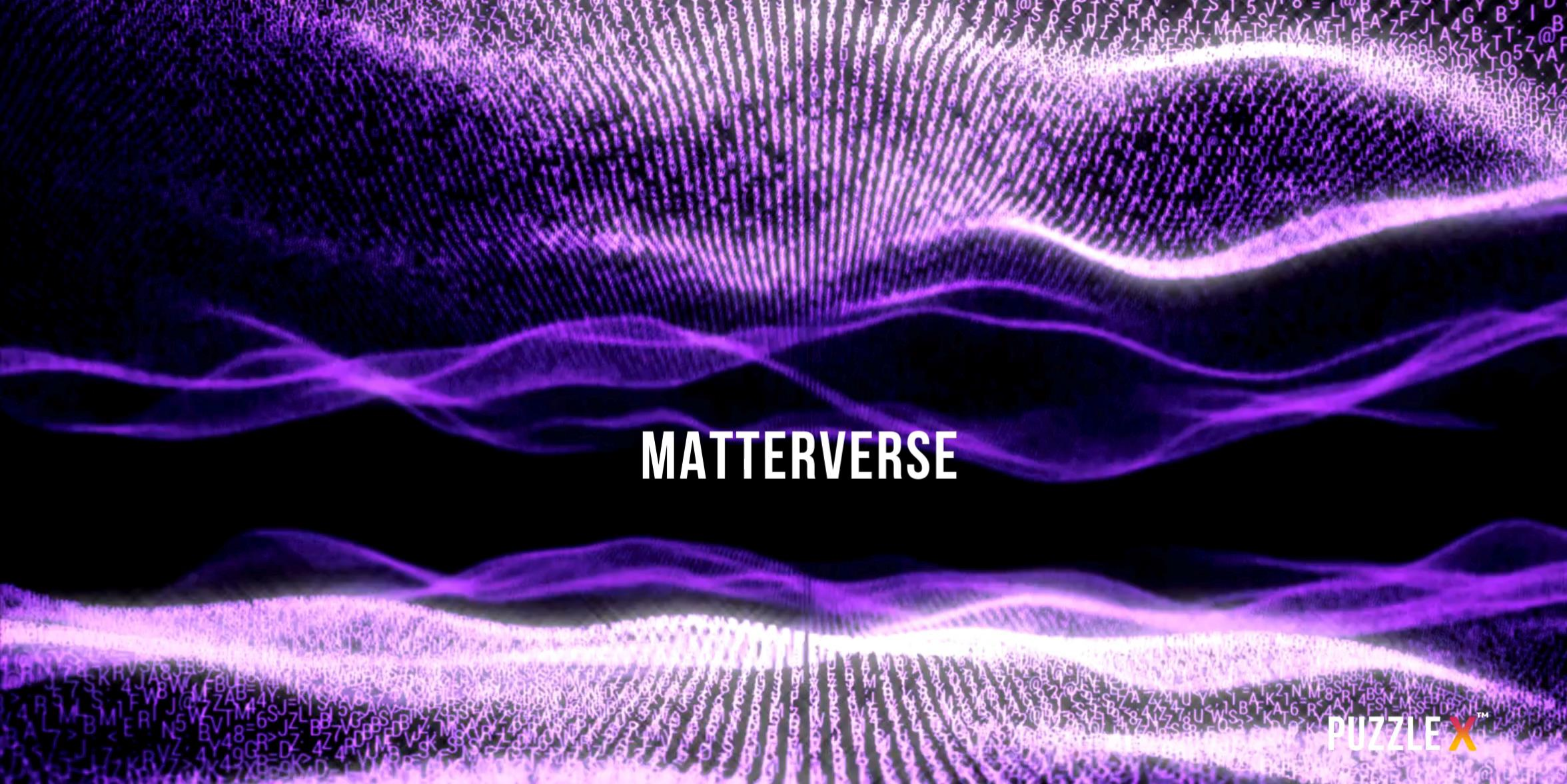
&

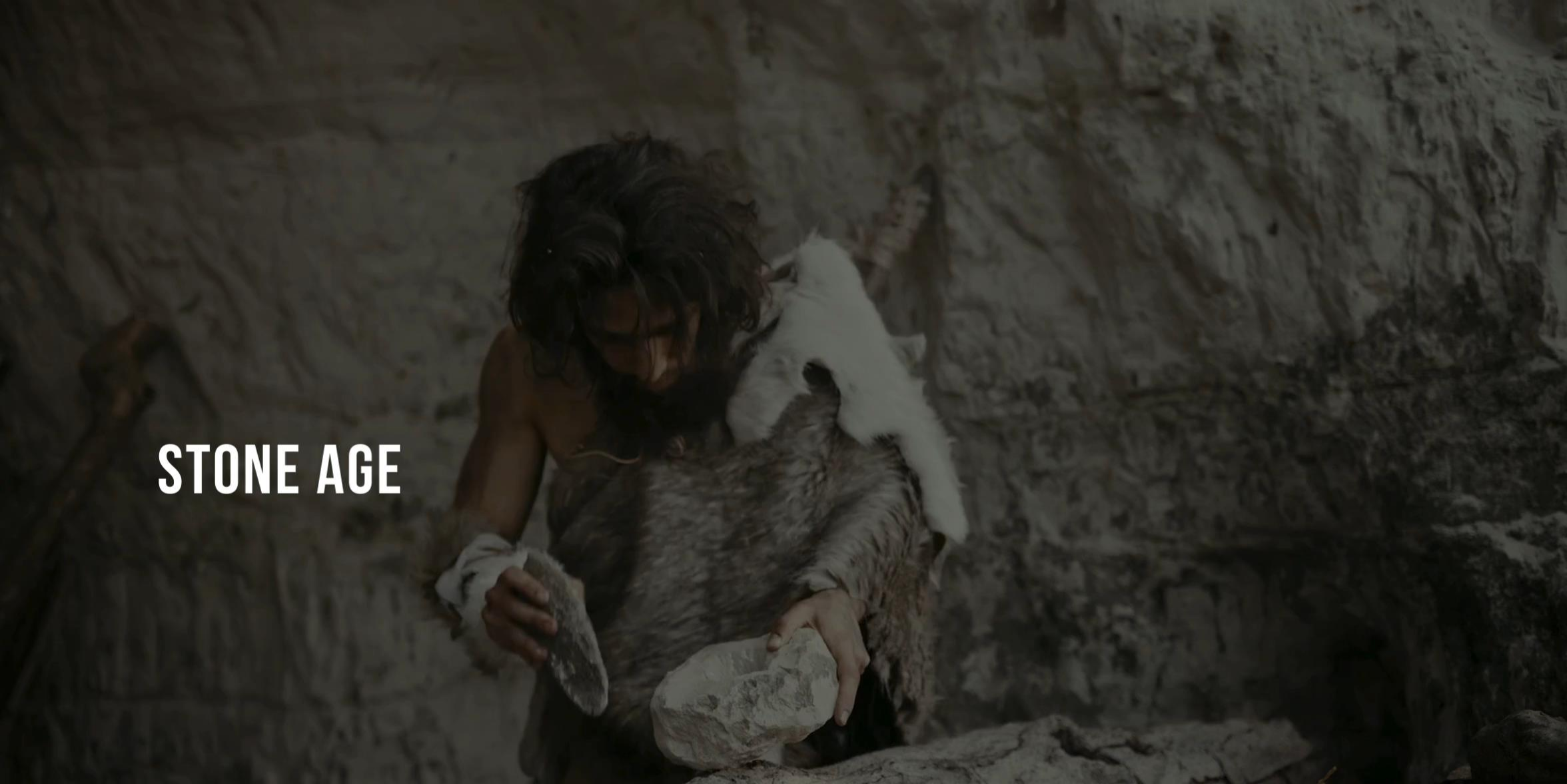
THE AGE OF EXPONENTIAL TECHNOLOGIES

PUZZLE X™

MATTERVERSE
PUZZLE X™

PUZZLE X™


MATTERVERSE
PUZZLE X™

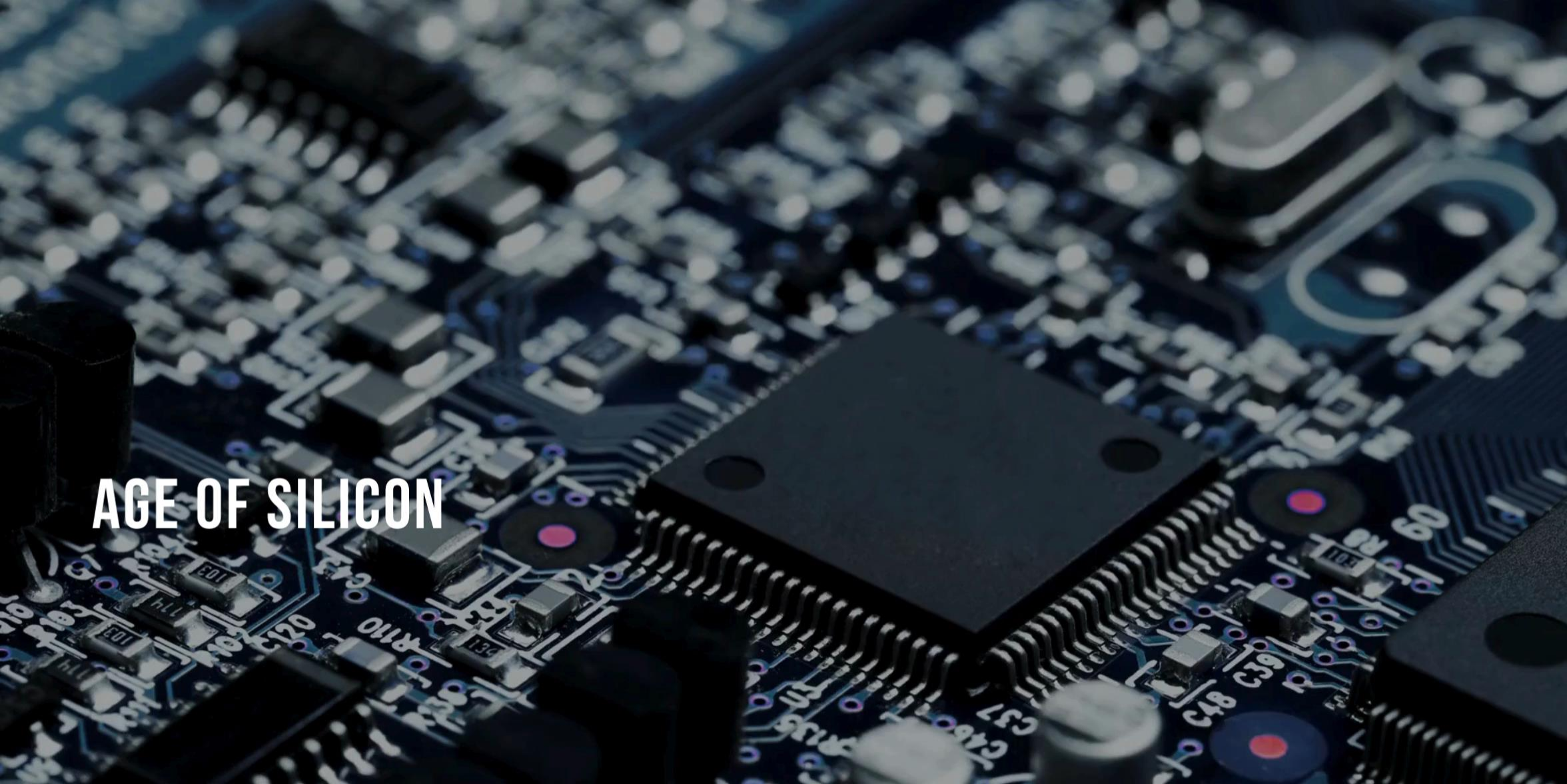

STONE AGE

STONE AGE

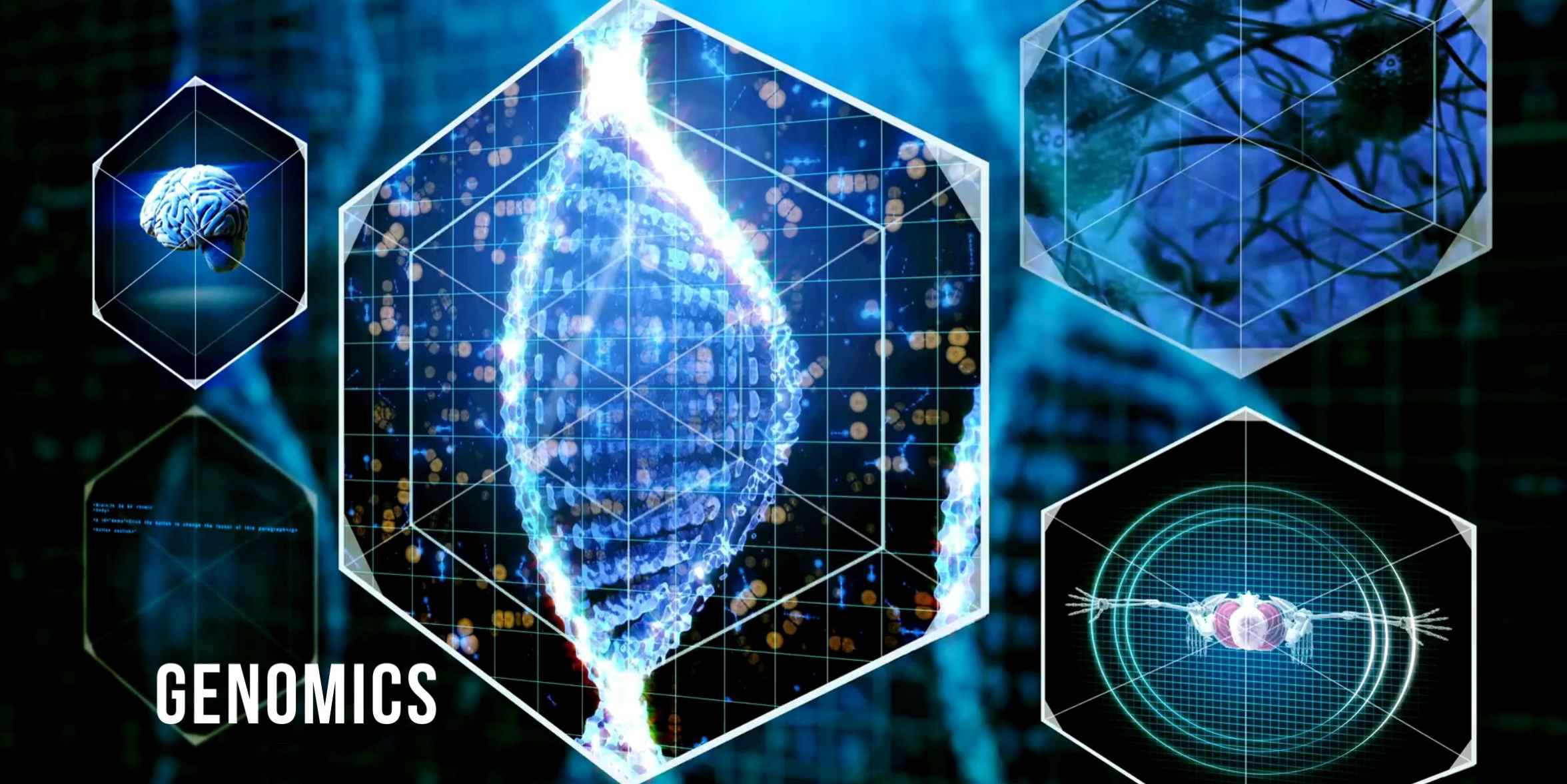
# BRONZE & IRON AGE

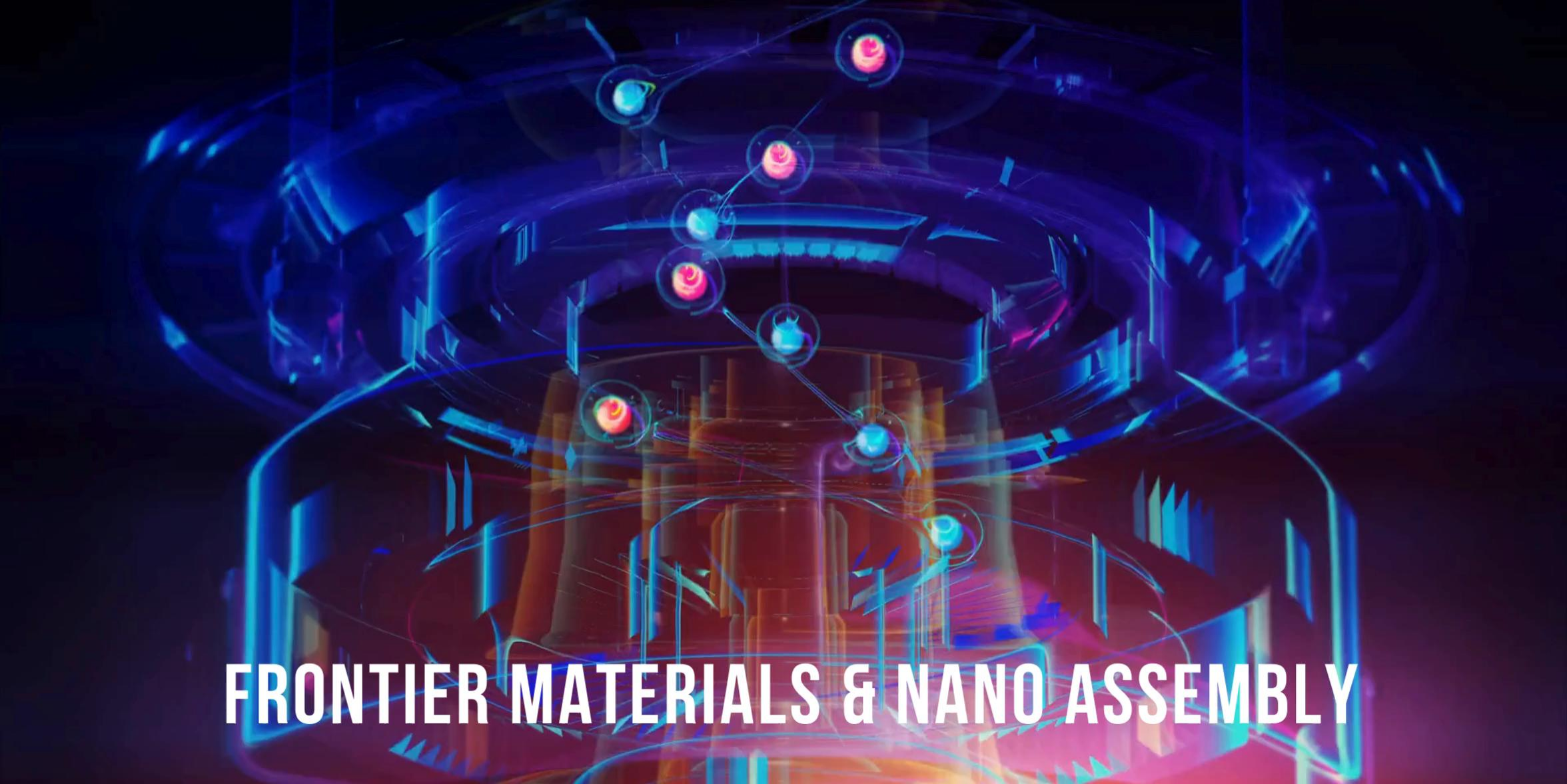
MODERN AGRICULTURE

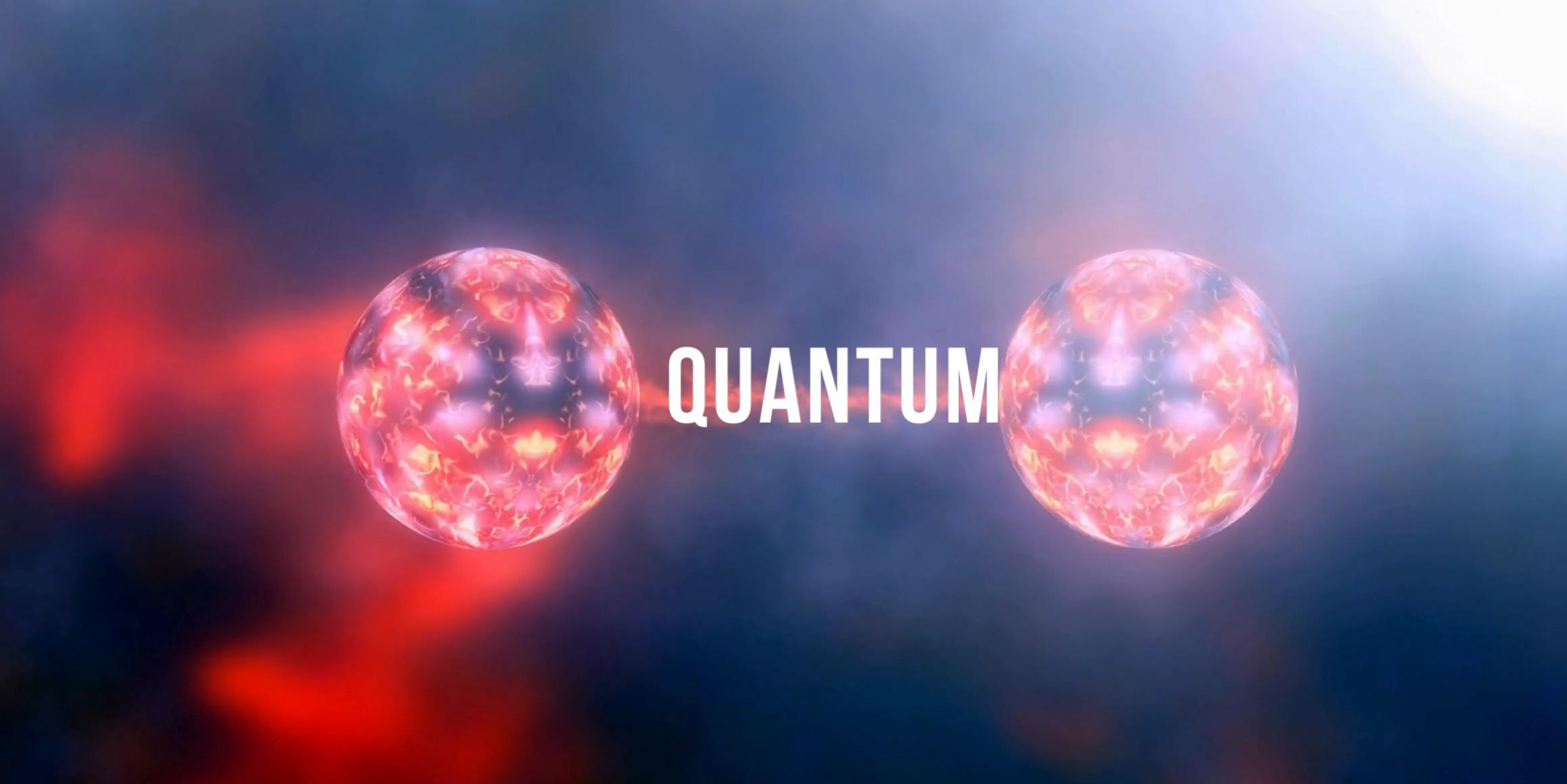
AGE OF ALUMINUM


AGE OF SILICON

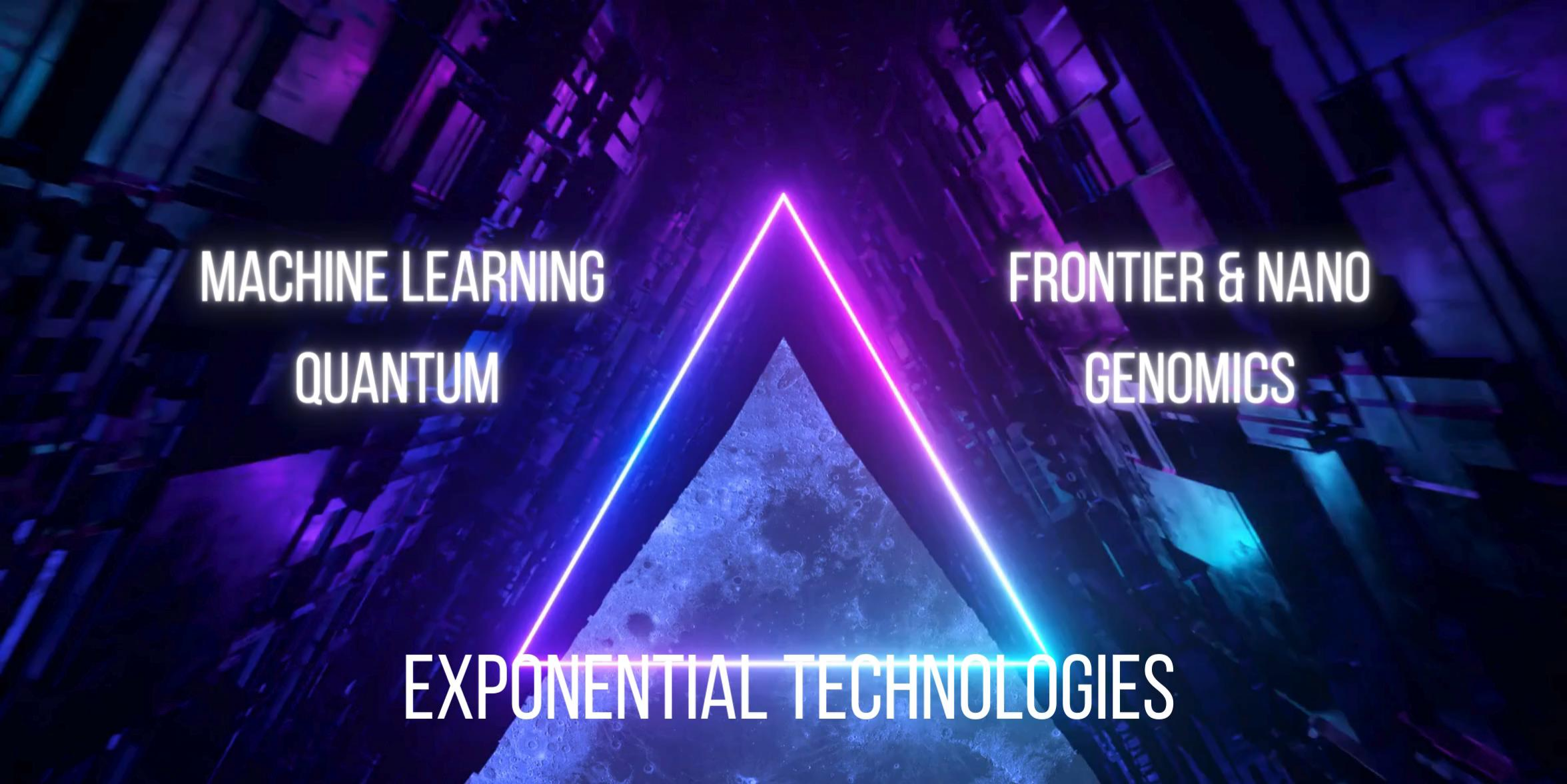
WELCOME TO THE ERA OF
EXPONENTIAL TECHNOLOGY


GENOMICS

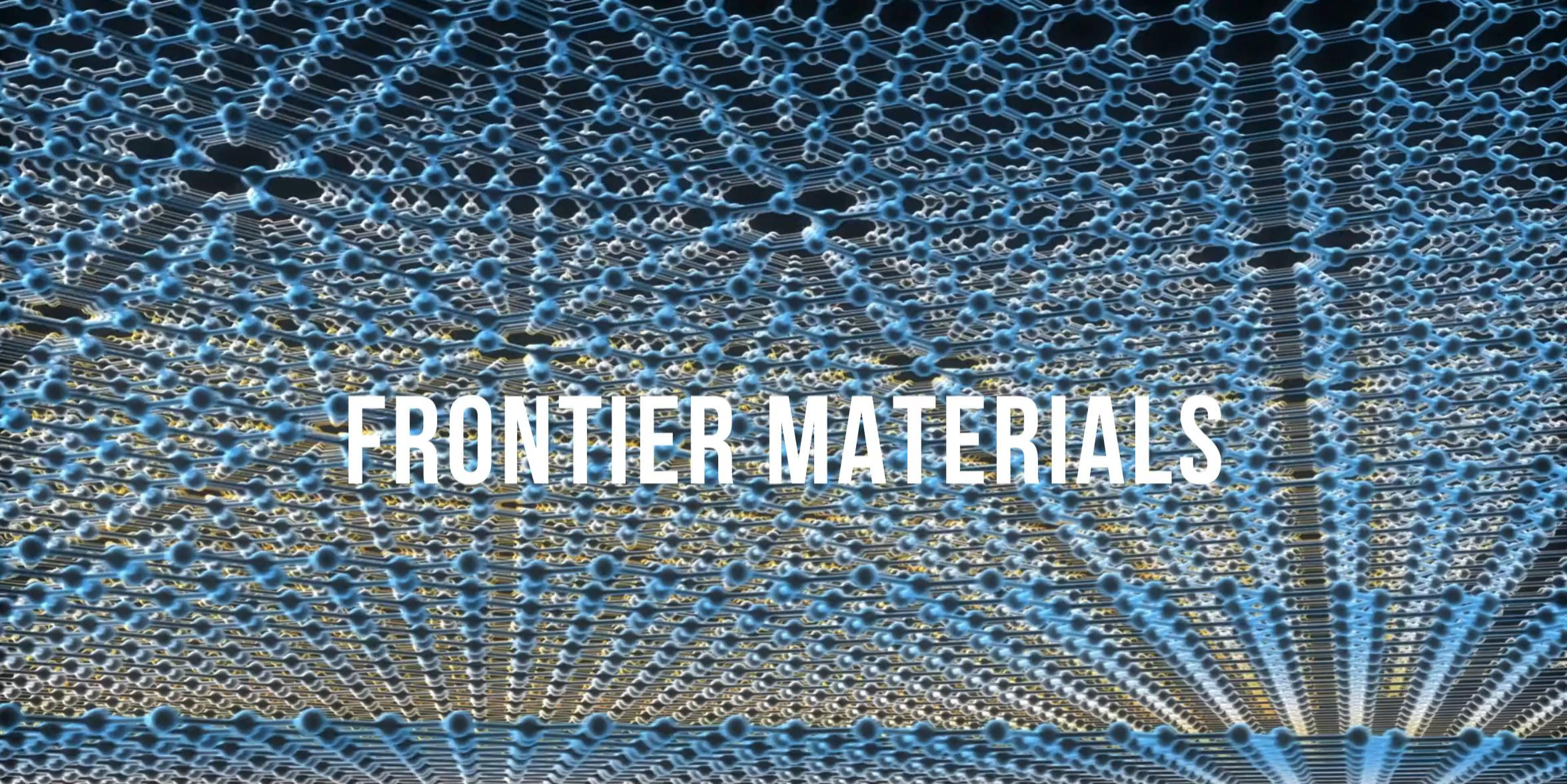

FRONTIER MATERIALS & NANO ASSEMBLY


QUANTUM

AI & MACHINE LEARNING

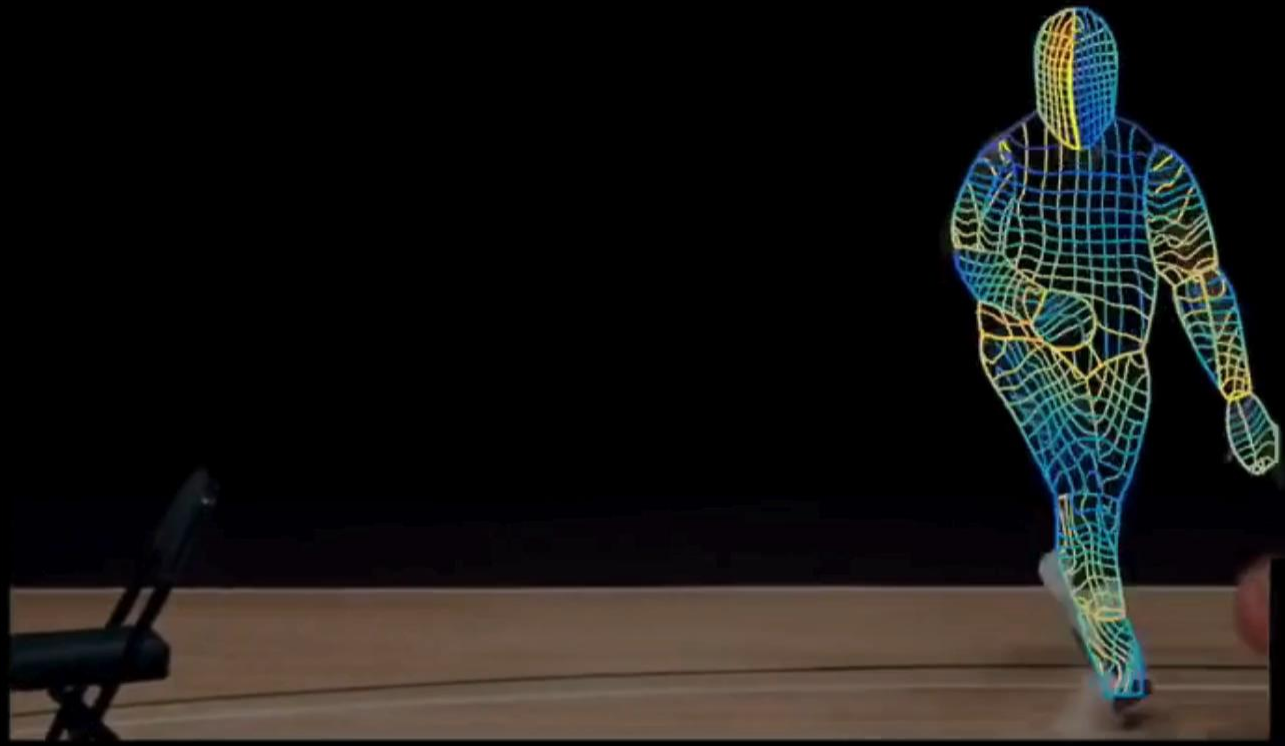

MACHINE LEARNING
QUANTUM
FRONTIER & NANO
GENOMICS
EXPONENTIAL TECHNOLOGIES

# MASTERS OF MATTER


FRONTIER MATERIALS

Graphene Tattoo | Akinwande Lab | University of Texas Austin

Graphene Flexible Brain Digital Interface
Garrido et al. , ICN2



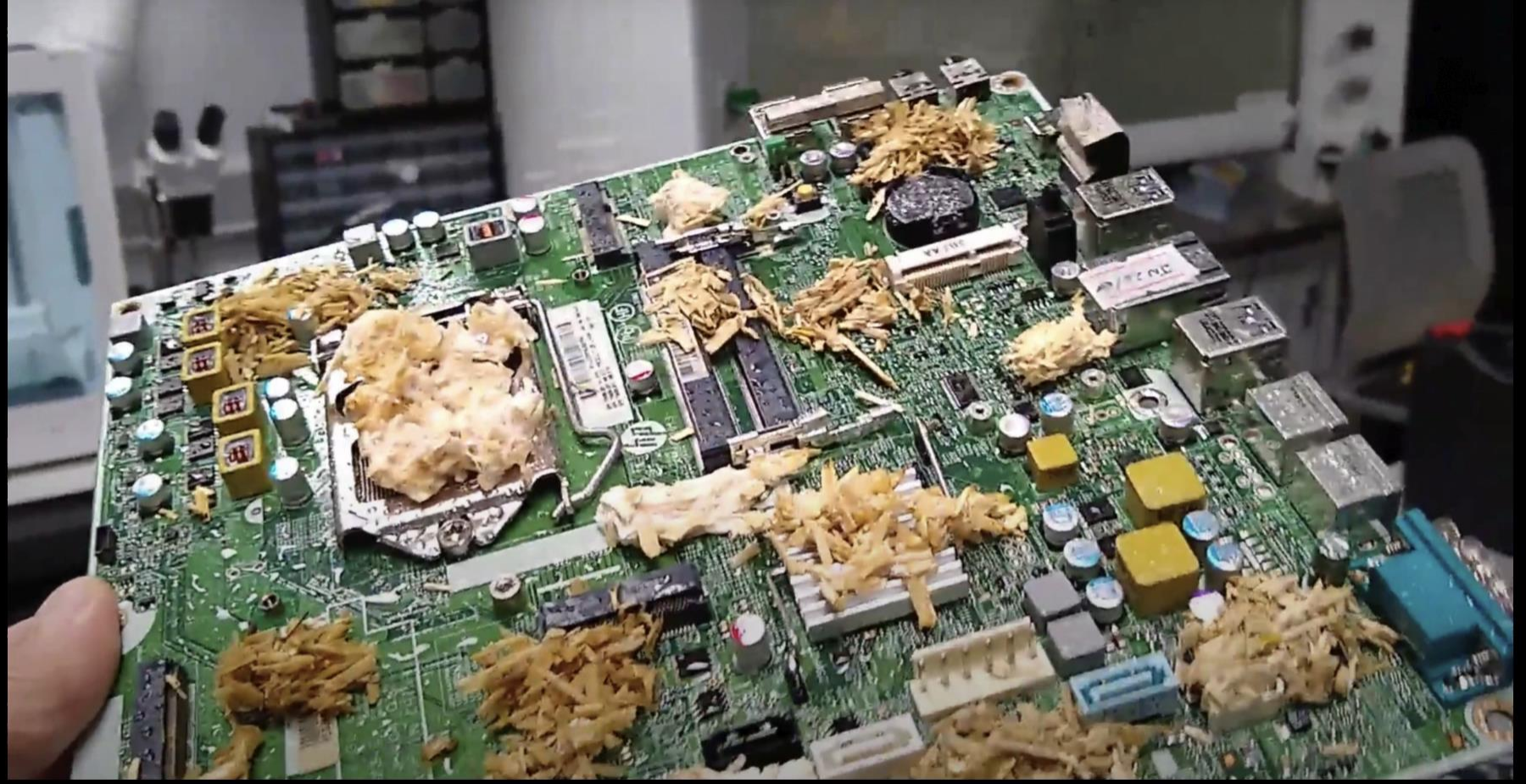
# WIFI SEEING THROUGH CONCERTE

De la Torre et. al. | Carnegie Mellon University

Detecting Explosives & Communicating | Nano Bionics using Carbon Nanotubes

Strano et al. , MIT

EXTINCT WOOLLY MAMMOTH MEATBALL
Vow



# EXOTIC COMPUTING | BIO COMPUTING

Andrew Adamatzky lab | University of the West of England

PUZZLE X™

Raster Plot of Neuron Activity
CORTICAL
00:18:47 [17.6, 61.0] [H/M:
gain: (1.1, 0.3)
Pong Game Environ
PUZZLE X™

THE MATTERVERSE

MWC24

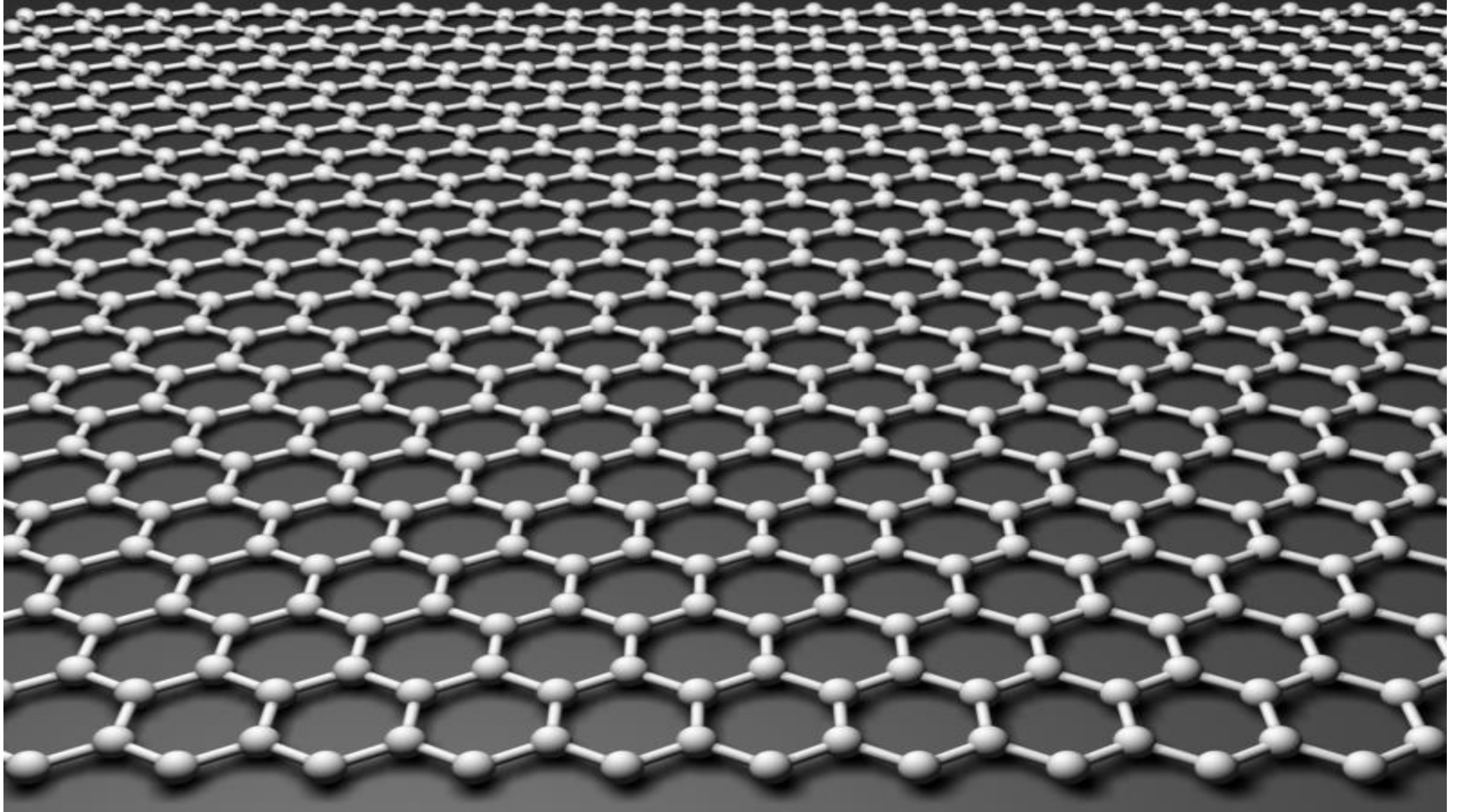
# Prof. Sir Konstantin Novoselov

Professor

National University of Singapore

NUS National University of Singapore

# Materials for the Future



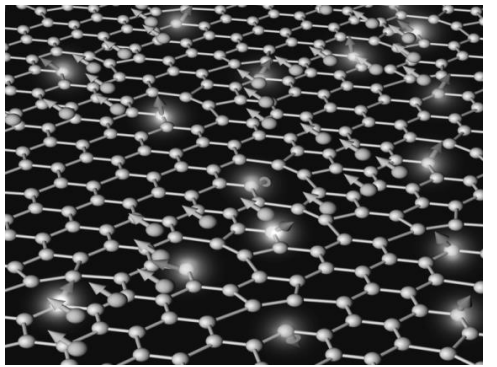
# Graphene Superlatives

Thinnest imaginable material

Very transparent

Most impermeable material

Permeation can be controlled

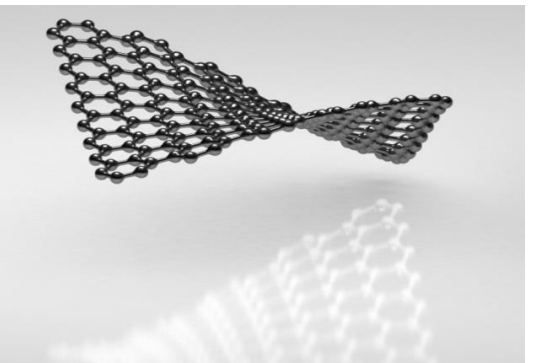


Record thermal conductivity

Highest current density

Highest intrinsic mobility

Ambipolar behavior



Strongest material

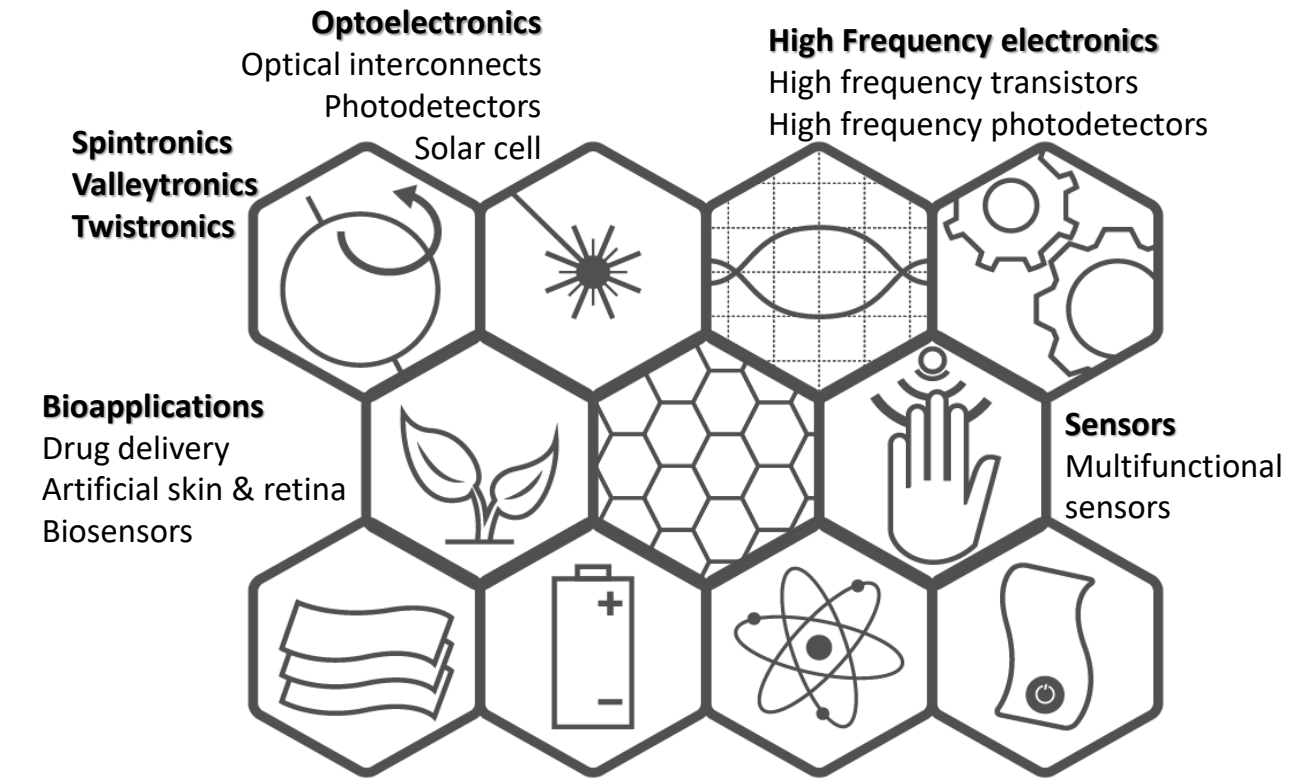
Stiffest known material

Strongly bendable

Most stretchable crystal

All those unique properties are combined in one material

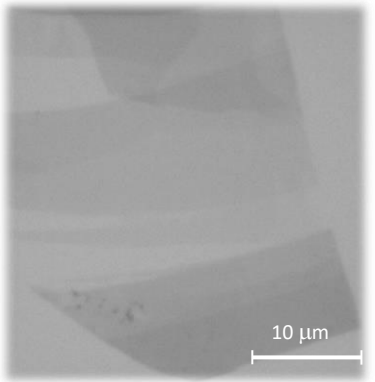
# Multiple possible applications

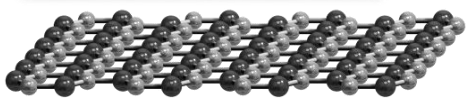


# Beyond graphene

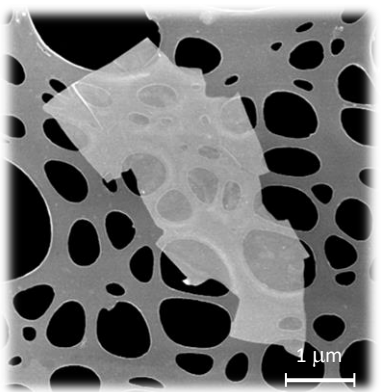
**2D crystals from other layered materials**

2D boron nitride in optics

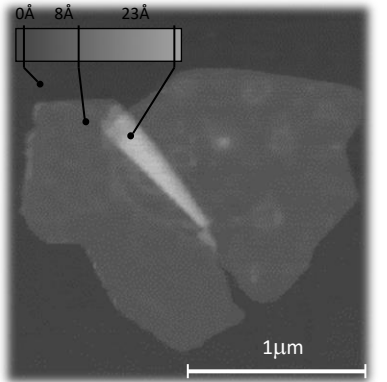


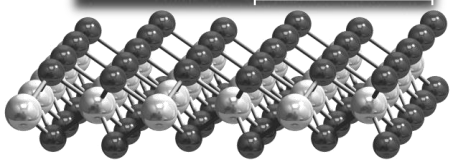
*Novoselov et al PNAS (2005)*

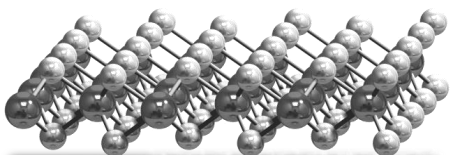


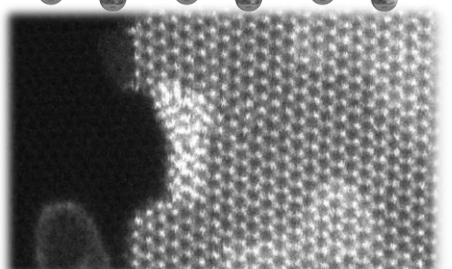

*SEM of 2D $Bi_2Sr_2CaCu_2O_x$*




*2D $NbSe_2$ in AFM*



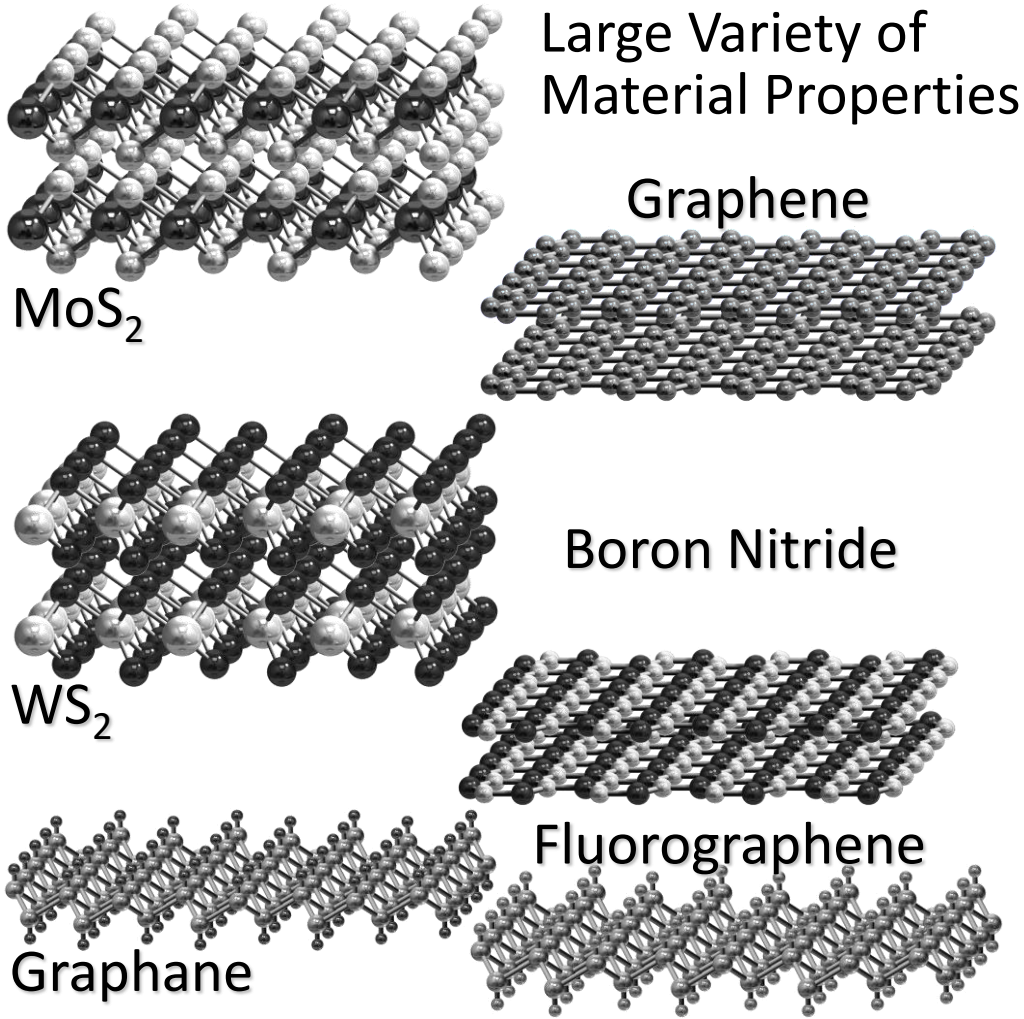




2D $MoS_2$ in TEM

**High Quality Different From 3D Precursor**

# Layer by layer material engineering



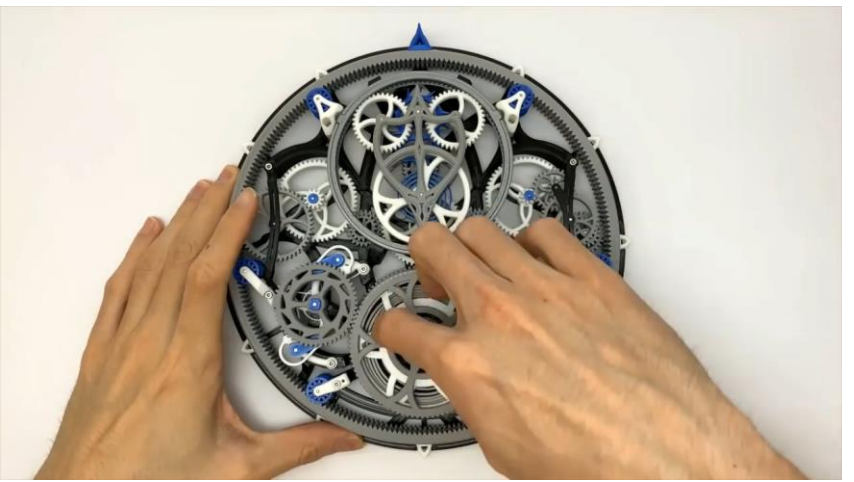
1991 expectations about 2029

**Bottom-up functionality** at the material & structural levels

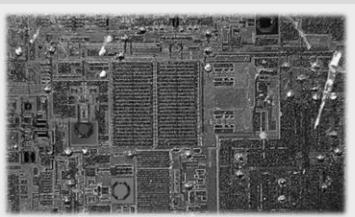
Reality in 2024 (still got 5 years to fix it)

**Top-down functionality** at the structural level only

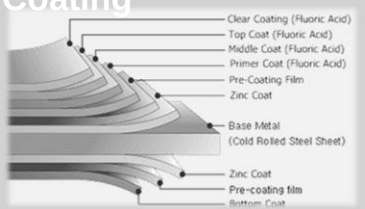
# Current technology: **top-down functionality**



**Electronics**



**Membranes & Coating**




**Bio & Healthcare**

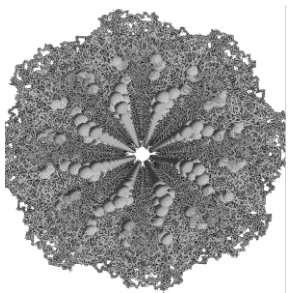
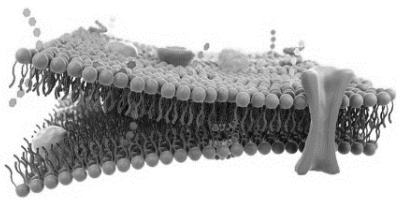
**Energy**

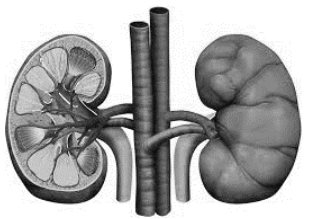
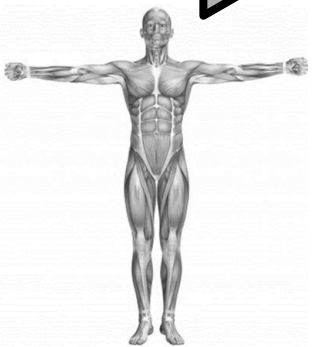
Not adaptive
Prone to faults

Requires constant control
Energy inefficient

# Nature: **bottom-up functionality**

Functionality distributed across all scales

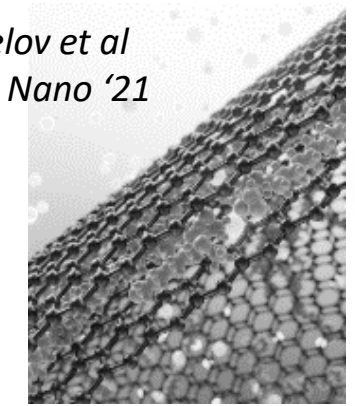
| Electronics | Membranes & Coating | Bio & Healthcare | Energy |
|---|---|---|---|

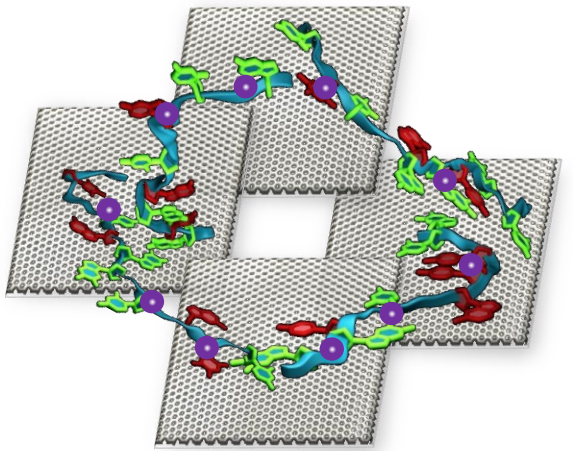
Adaptive Self-healing **Functionality at**
Versatile Energy efficient **the Material Level**

# Bottom-up functionality **at the material level**

## Smart Membranes

*Novoselov et al*
*Nature Nano '21*

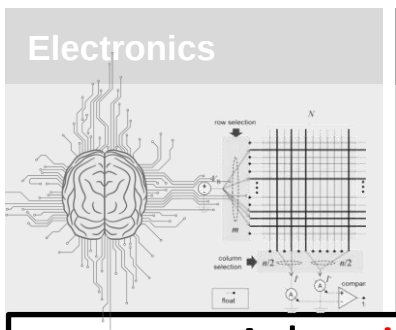


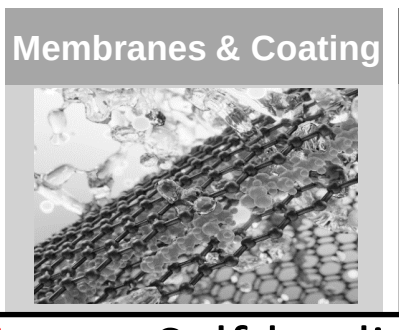


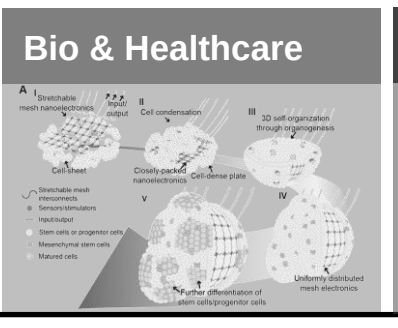
**Functional**
Programmable to perform
a complex response to external stimuli

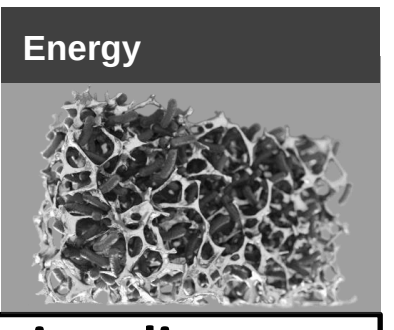
**Intelligent**
Have memory: can learn to perform
a particular function

**Materials**



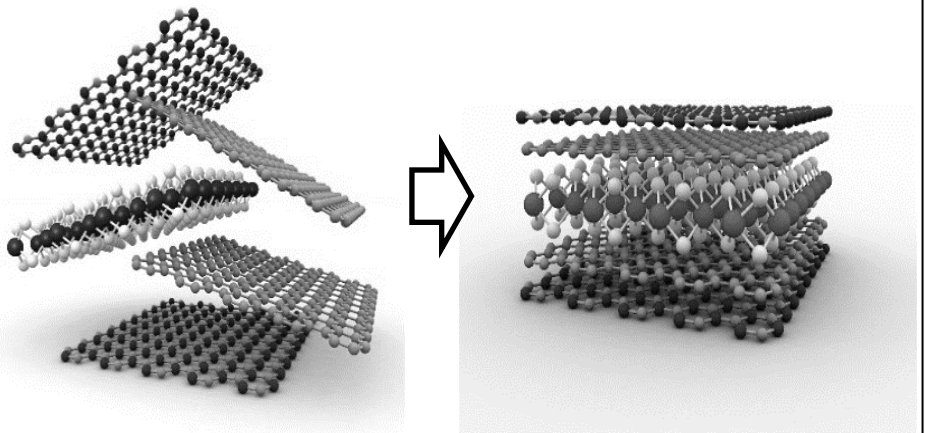



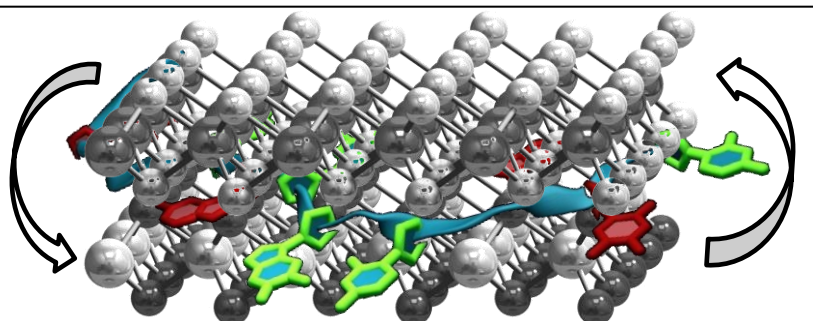




Adaptive Self-healing **Functionality at**
Versatile Energy efficient **the Material Level**

# Principles of materials design

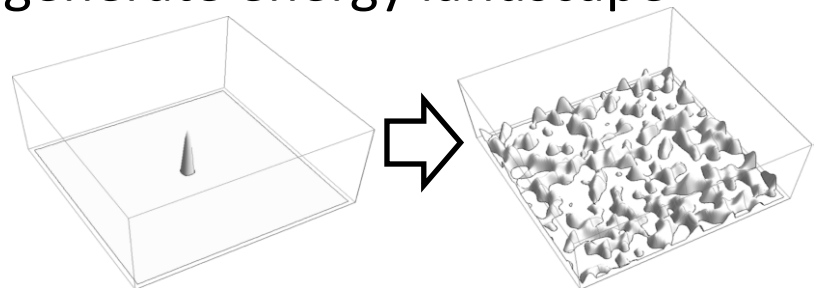


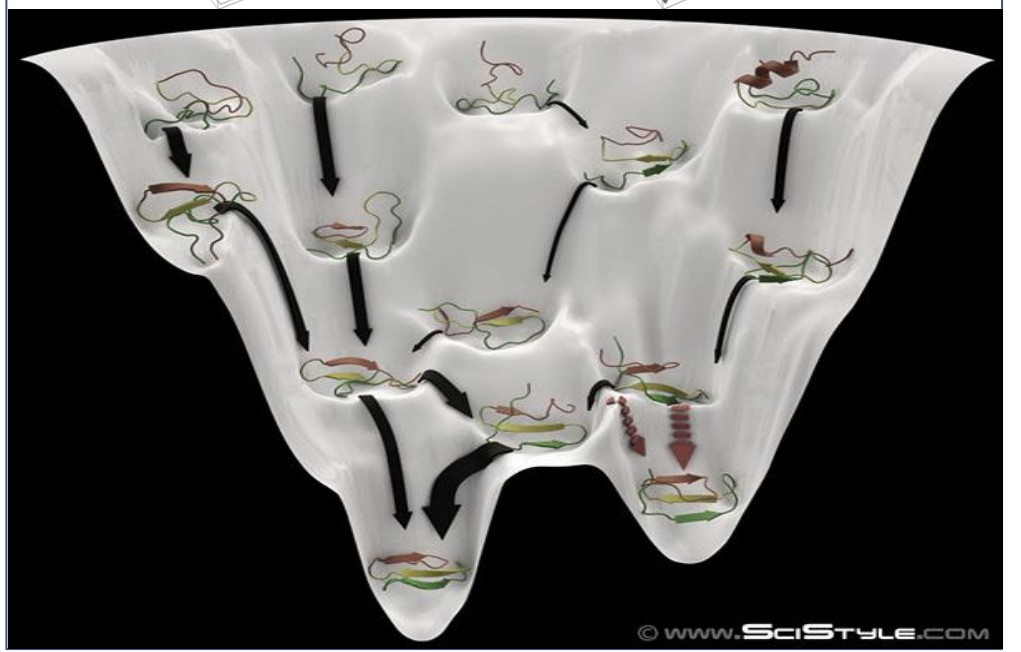
Strong interaction



Multiple interaction channels between the components

Degenerate energy landscape





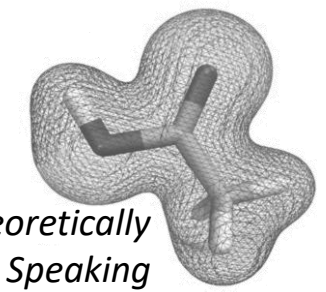
# Framework for the development of FIMs

## Physical Formalism

Basic Physics Constrains

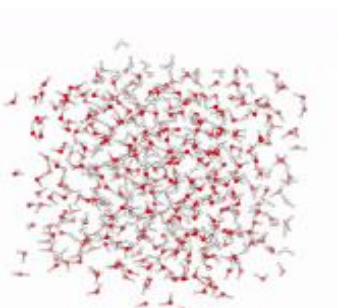
$$i\hbar \frac{\partial \Psi}{\partial t} = \hat{H}\Psi$$

Density Functional Theory



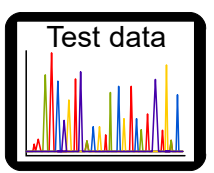
*Theoretically Speaking*

Molecular Dynamic Simulation

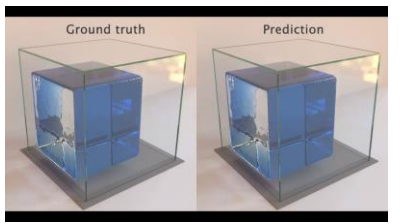


*Wikipedia*

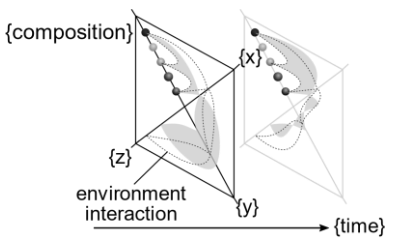
## Material Robotics Lab



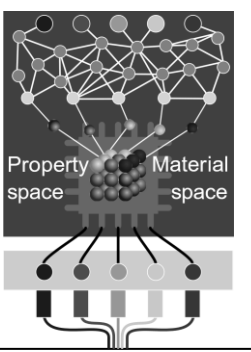
## Dynamic Machine Learning




Differentiable programming (e.g. JAX MD)




Identifying Memory States



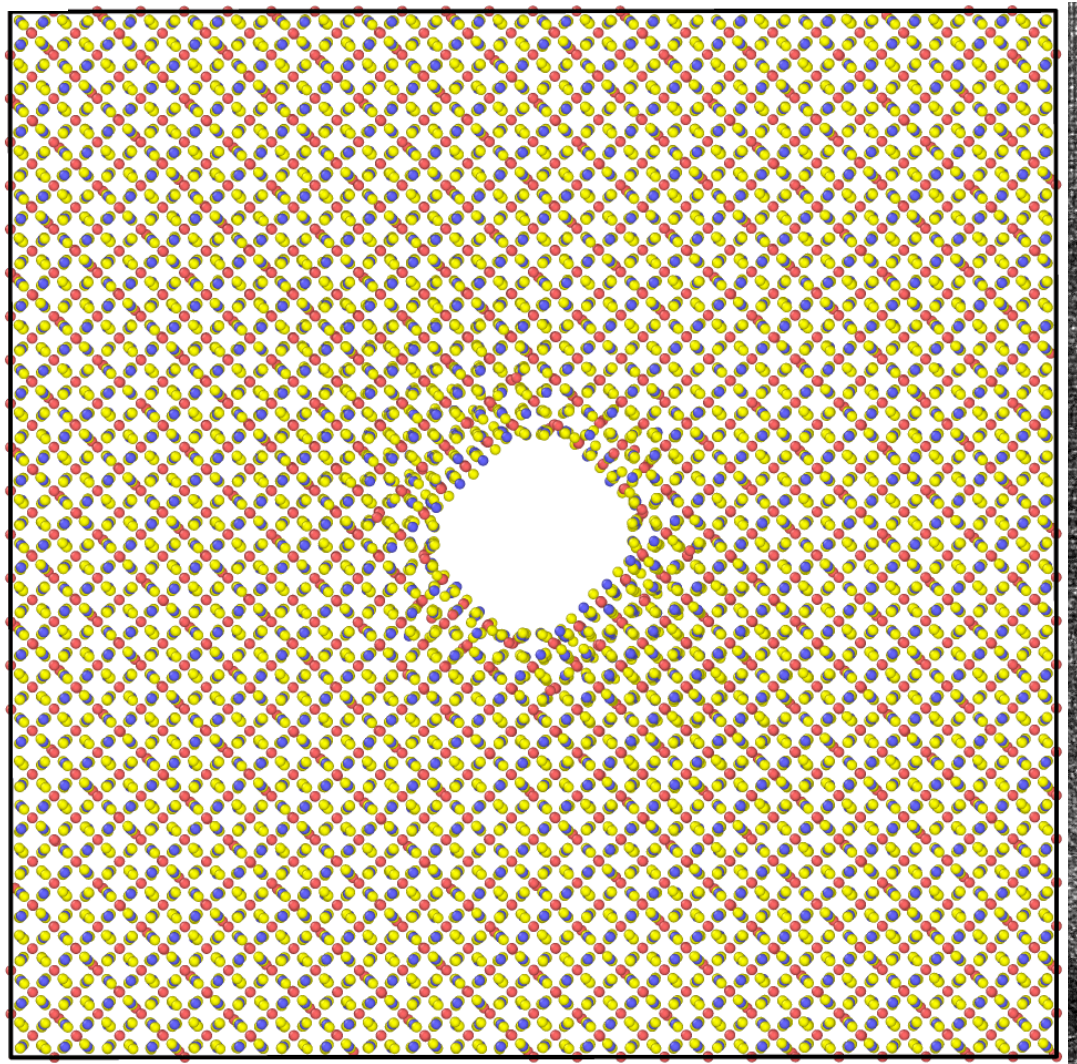

Solving Inverse Problem

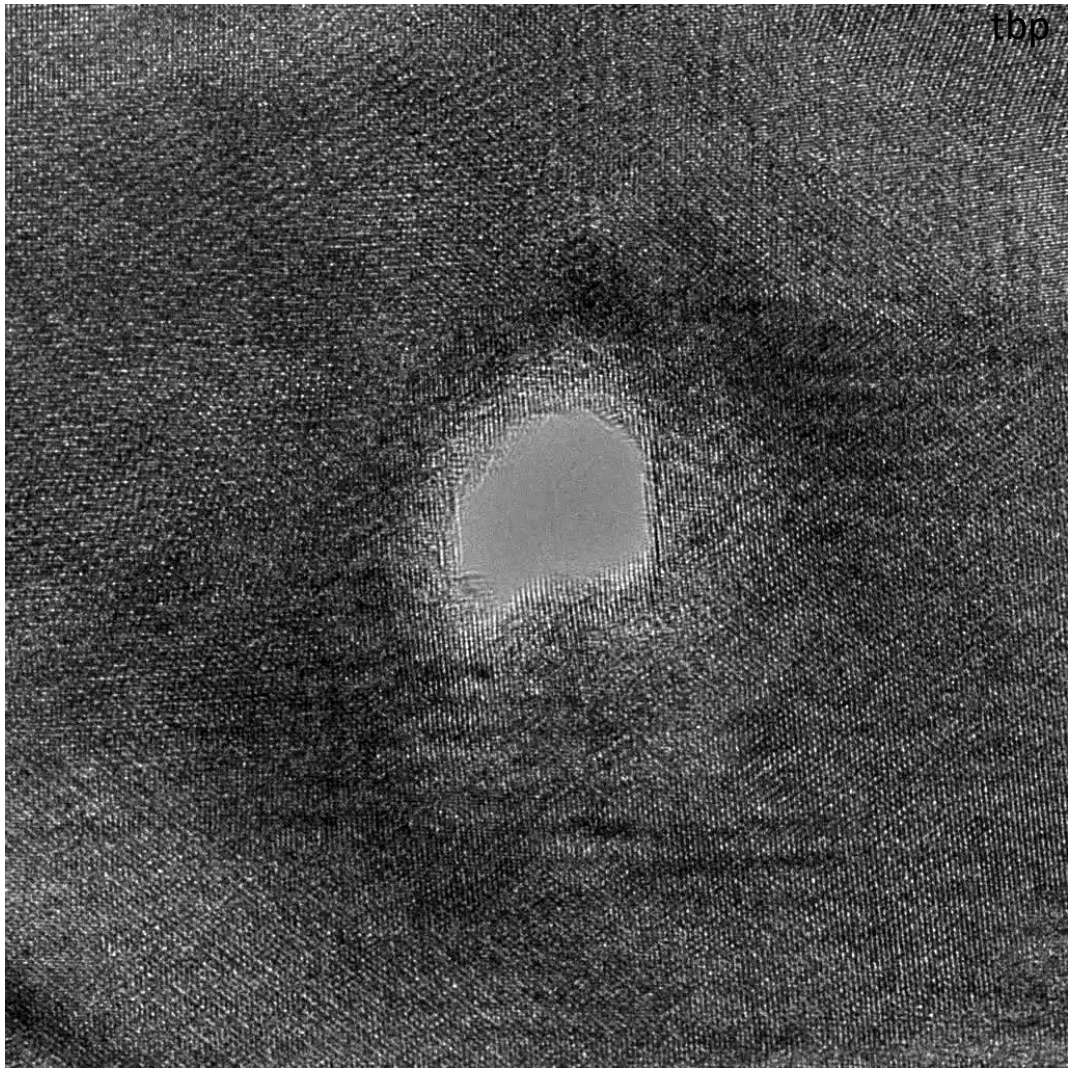
*Andreeva, Skorb et al. In preparation*

*Kedar Hippalgaonkar, Institute for Functional Intelligent Materials*

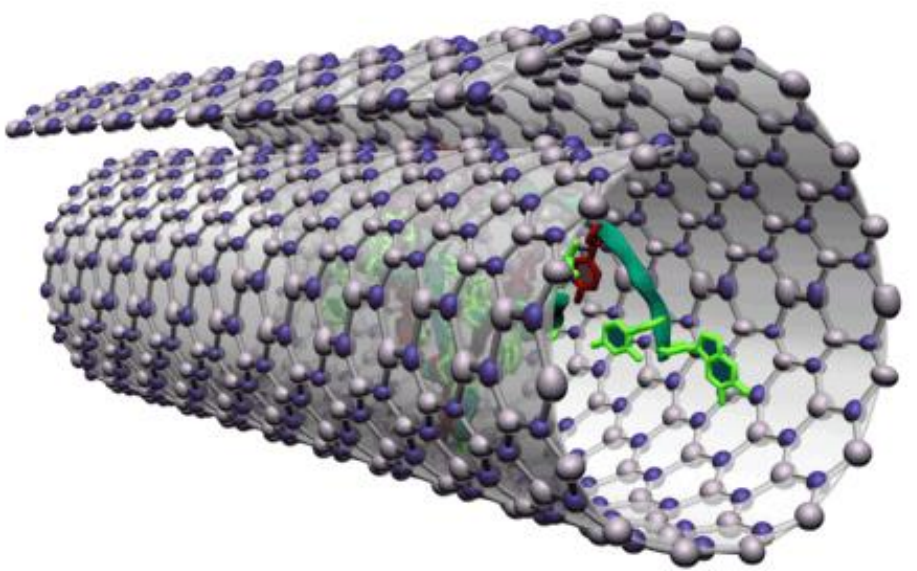
# Out of equilibrium properties of materials

Zongwen Liu,
Pengru Huang,
tbp



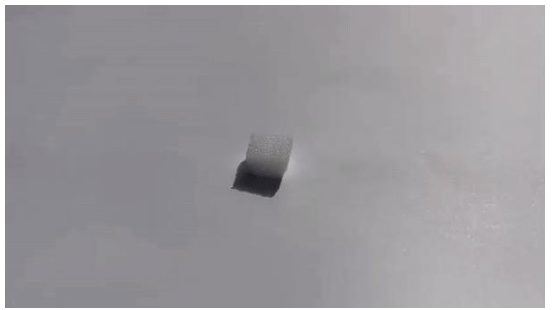


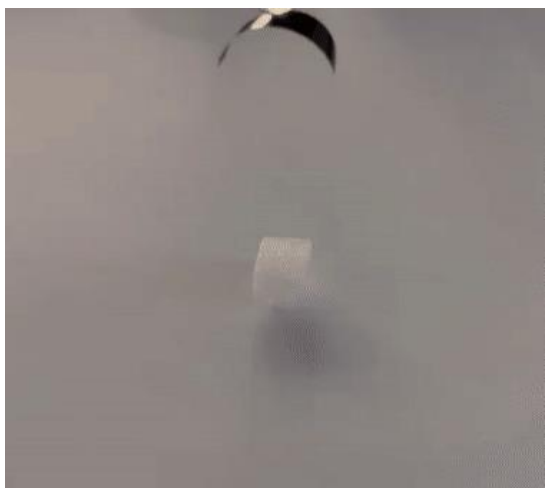
# Smart drug delivery

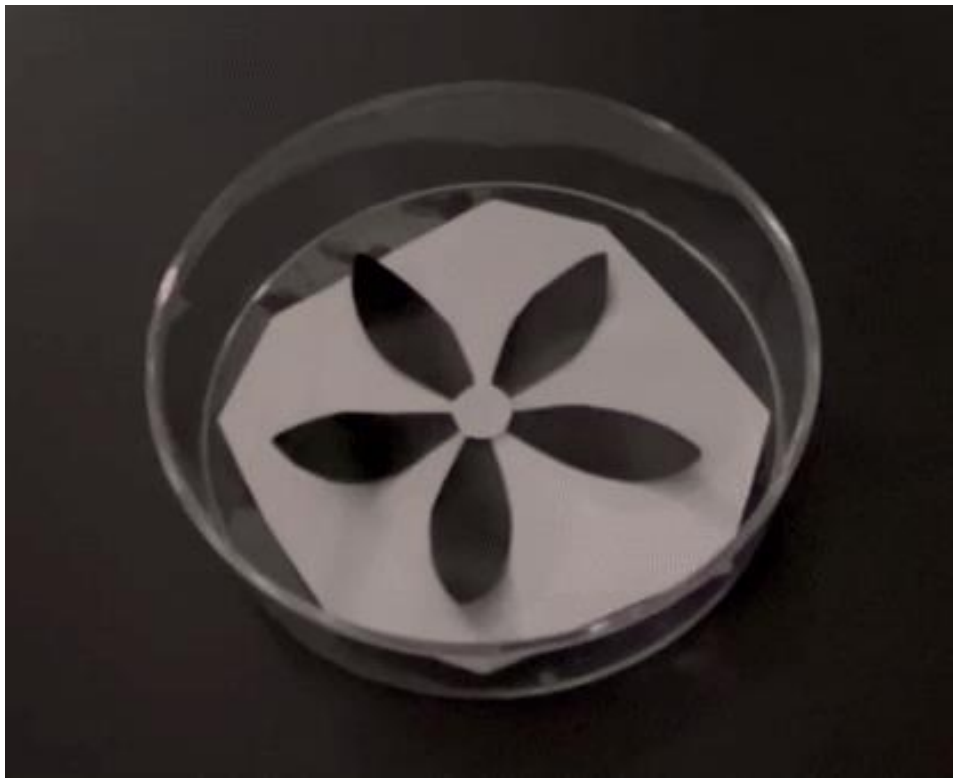


# 2D actuators

*Qian Wang et al manuscript in preparation*

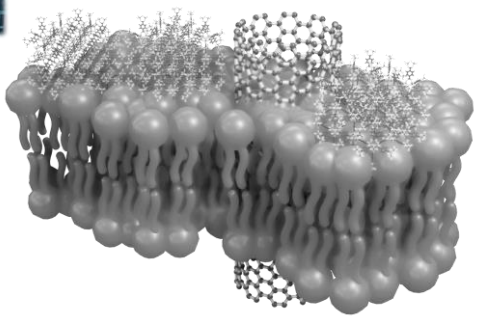




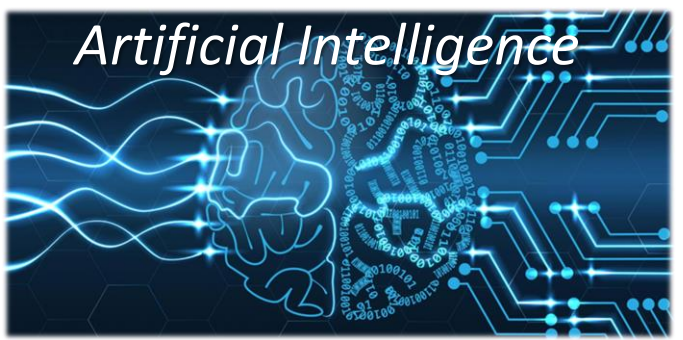


*Courtesy Gui Bazan, Institute for Functional Intelligent Materials*

# Solving Worlds Most Important Sustainability Issues



Functional
Intelligent
Materials



MWC24

# Rika Nakazawa

Group VP, New Ventures & Innovation

NTT DATA

# Innovating with Innovative Materials (Particles) of the Future

## Silicon Photonics and Sustainable Networks of the Future

Rika Nakazawa
Group Vice President, New Ventures & Innovation
NTT DATA Inc

# Using Alternative Power in Nature for Sustainable Growth through Technology

## Beyond Human

- Future Sensor + AI Systems
- **For the machine** (AI) to process
- That sense information humans can't recognize,
- Enables millisecond-order autonomous control

More valuable if you can control it on the **order of milliseconds.**

## For Human

- Traditional digital systems
- For human confirmation and use
- Information within human perception
- Transfer with a sense of speed of human activities

Communicated / transmitted **in a few seconds**.
We can't respond in 0.1 seconds.

### Cognitive and Communication Capacity

How finely, precisely, and multisensory the system can capture objects in the physical world and process the captured data.

**Beyond Human (Natural)**
**20-150,000 Hz sound, 120 FPS motion, etc.**

Human-Level (High-Quality Digital)
20-20,000 Hz sound, 30 FPS motion, encoded at fine-for-human quality

Low Quality Digital
10 FPS motion, etc.

### Response Speed

How responsively the system can react to an event. Can be represented with turn around time (TAT).

**Beyond Human (Natural)**
**Act in 10 msec**

Human-Level
Act in 0.1 second

Act in a second

Act after several minutes

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# Requirement from Advanced Applications

Reduction of network latency is essential for robotics, Autonomous driving, AR/VR, etc.

**Small**
**Less than a few msec**

**Tolerable latency**
**Several 10msec**

**Several 1,000 msec**
**Large**

- Autonomous driving/ traffic control
- Robots/drones
- AR／VR
- Teleconferencing
- Video streaming
- High-capacity storage

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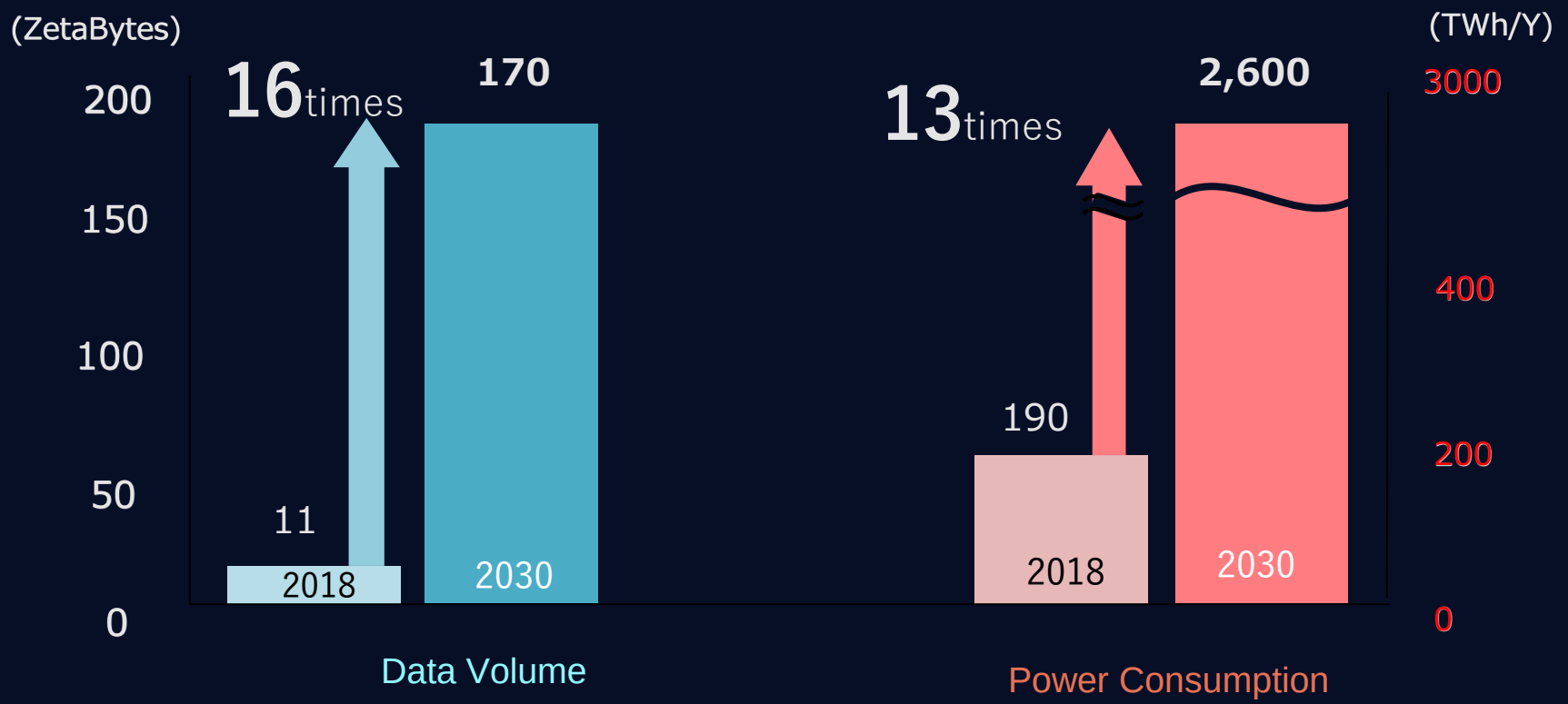
# Global Data Centers:
# Data Volume | Power Consumption




※Center for Low Carbon Society Strategy, Japan Science and Technology Agency

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# Innovative Optical and Wireless Network powered by Optics “Materials”

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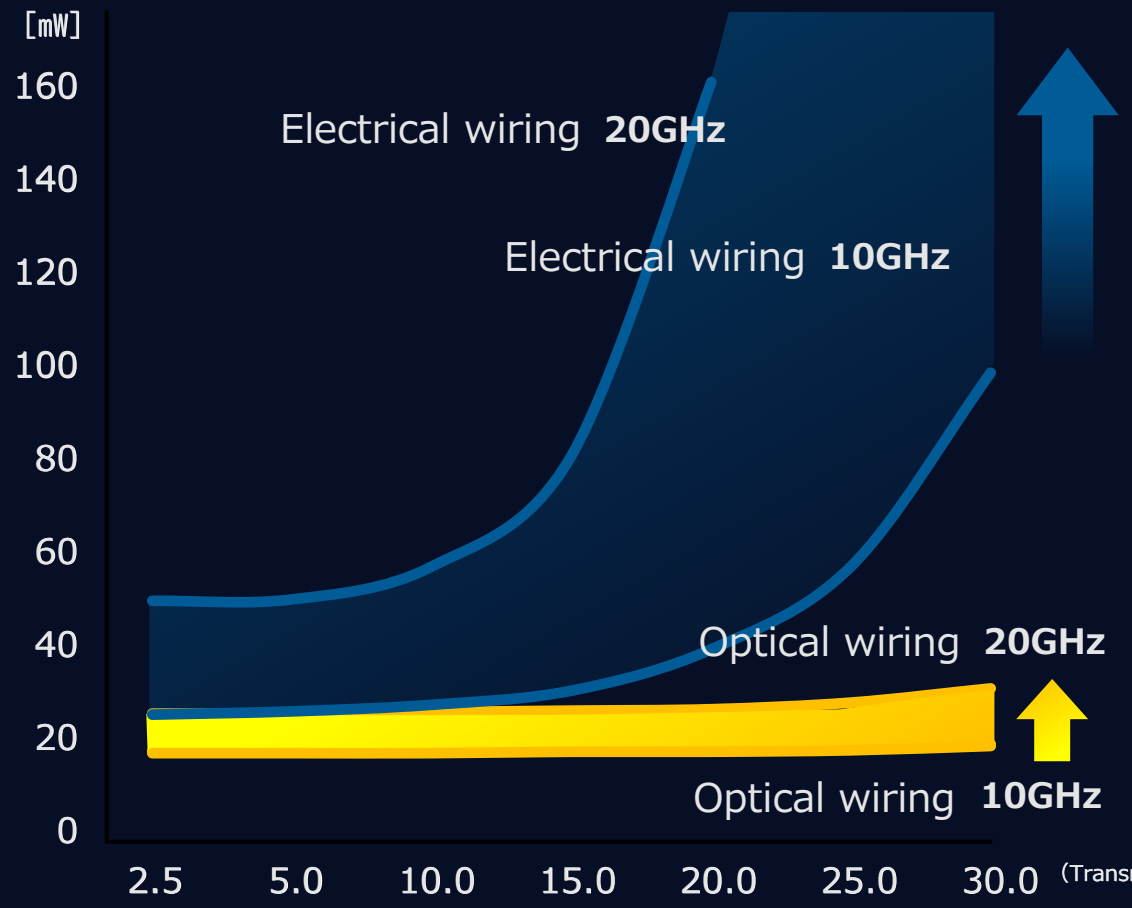
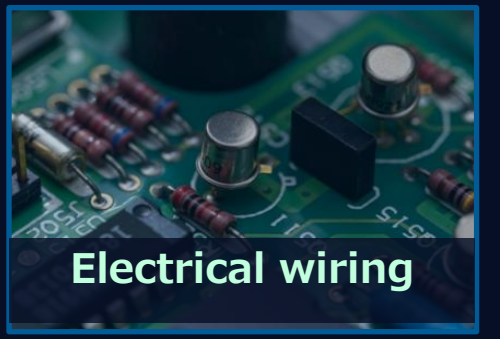
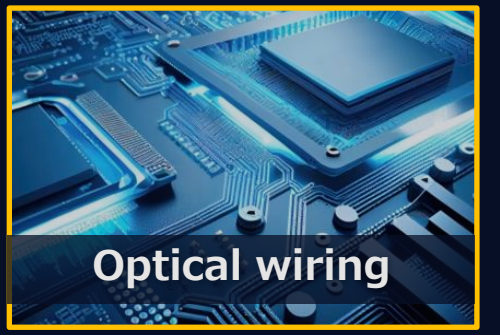
# Why Optics




Source: Material from NEDO Optoelectronics Symposium (June 16, 2015)

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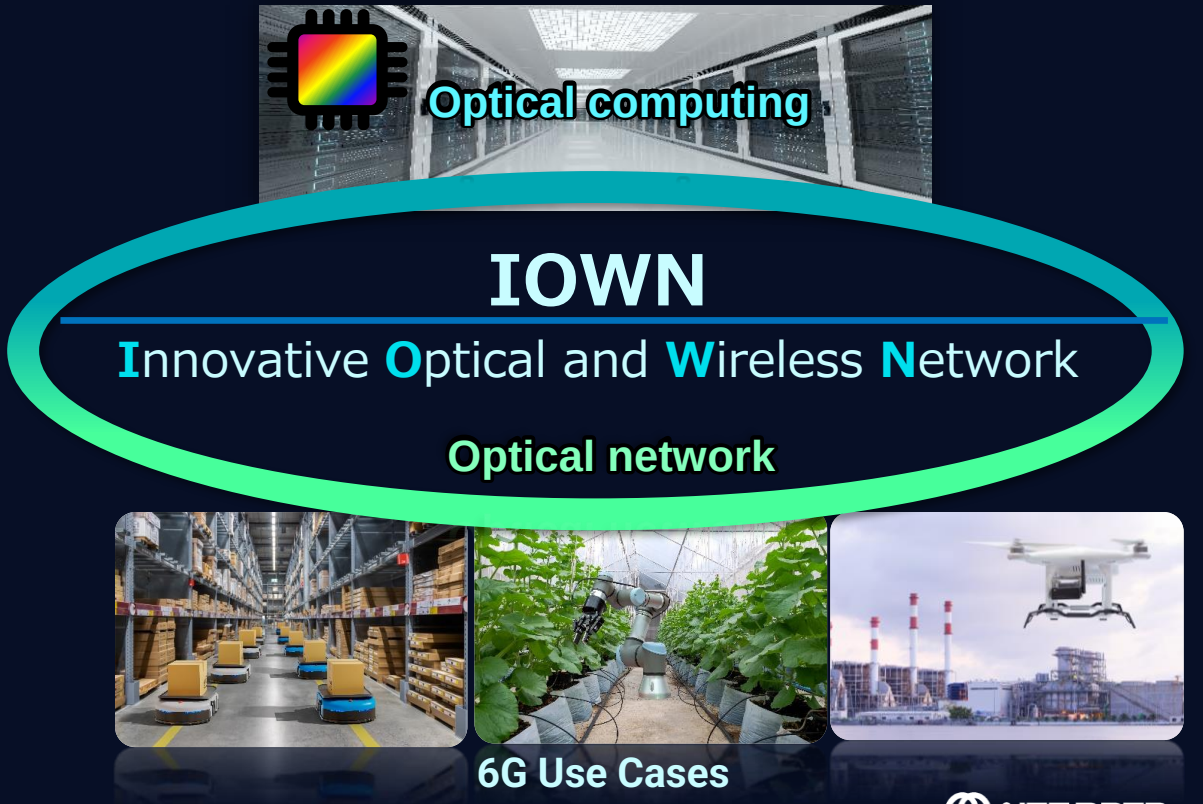
# IOWN:

**Next Generation Optical Network & Computing Infrastructure**

**High-capacity/ high-quality**

**Low-power consumption**

**Low latency**

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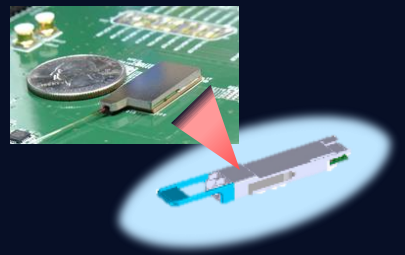
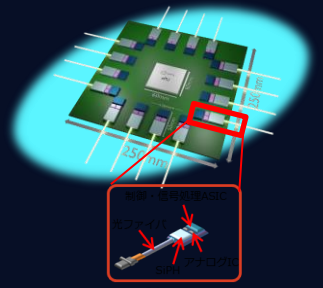
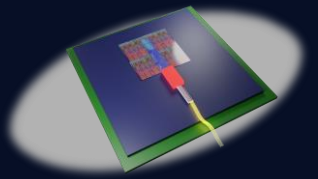
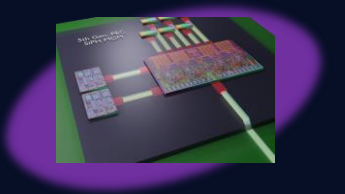
# Power Efficient
# Photonics-electronics Convergence Devices

| IOWN1.0 | | IOWN2.0 | IOWN3.0 | IOWN4.0 |
|---|---|---|---|---|
| 1st generation | 2nd generation | 3rd generation | 4th generation | 5th generation |
| For relay devices | For pluggable transceivers | For board connection | For chip connection | Fiber-less |









Telecom relay device

Transmission device between data centers

- Ultrafast switch
- SmartNIC

Photonic disaggregated computer

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# Particles and Material Science

| “Transmitting” Photonics | “Data Processing” Electronics ⇨Photonics |
| --- | --- |

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# IOWN Computing

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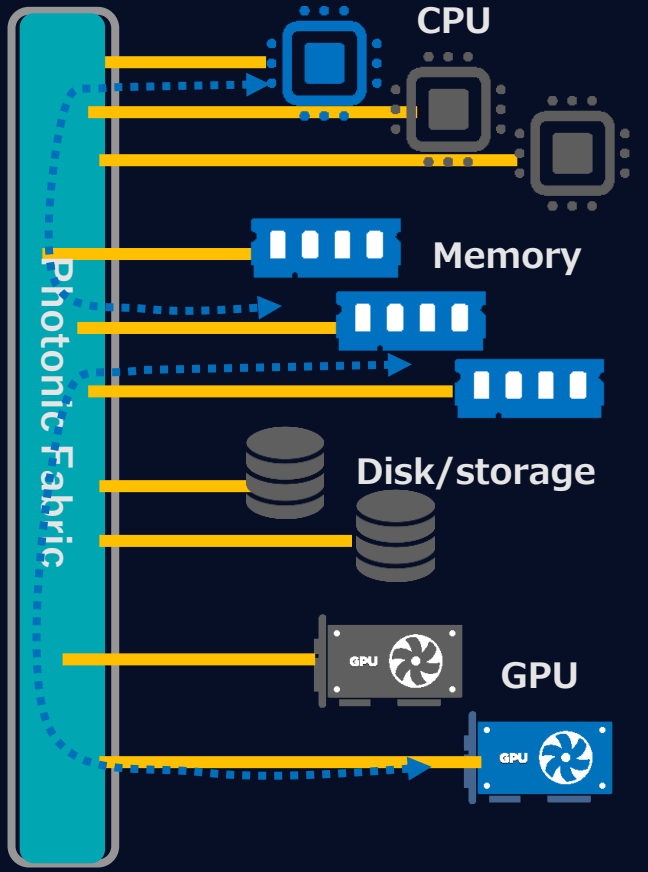
## IOWN computing:
# Photonic Disaggregated Computing

- Centers around data (memory) where only necessary components operate
- Connect devices over long distances using optical wiring

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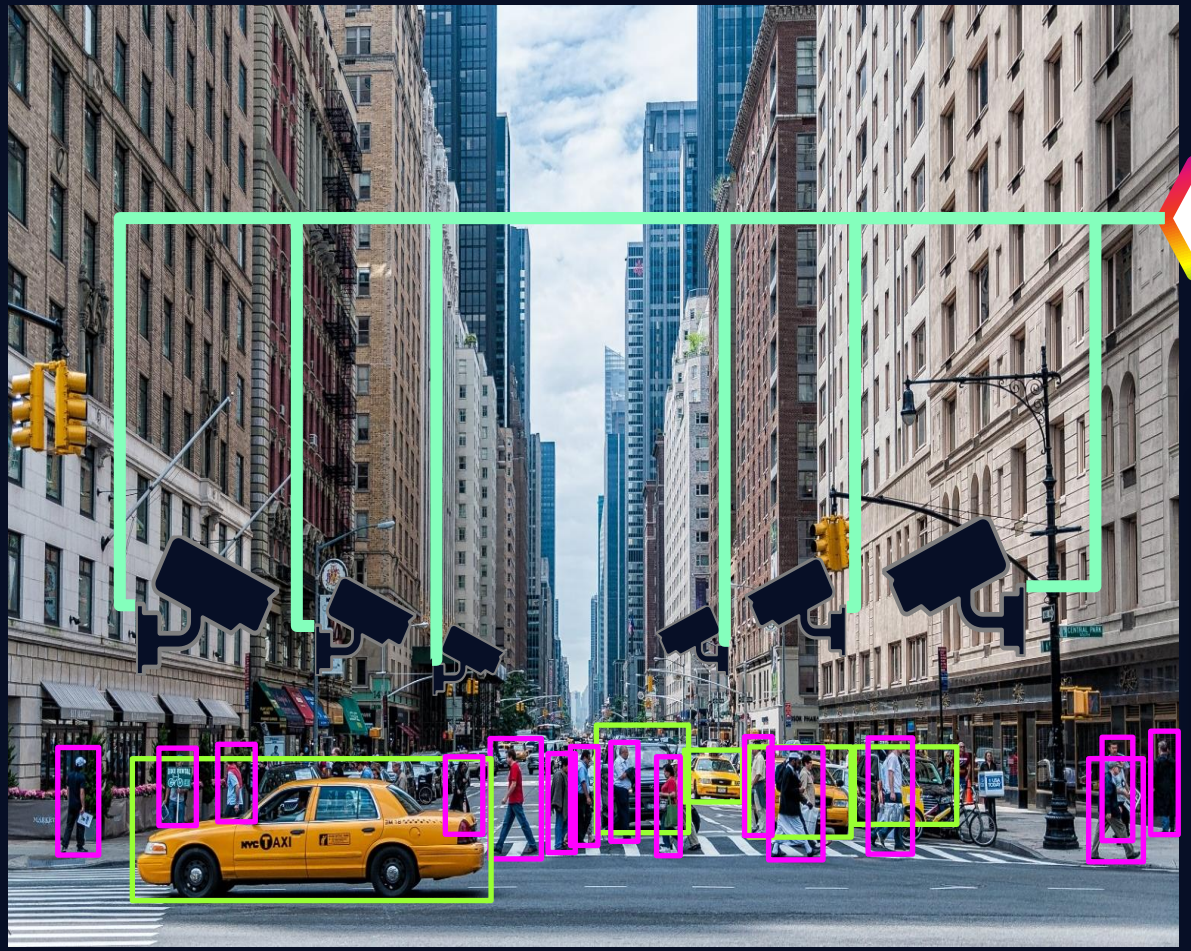
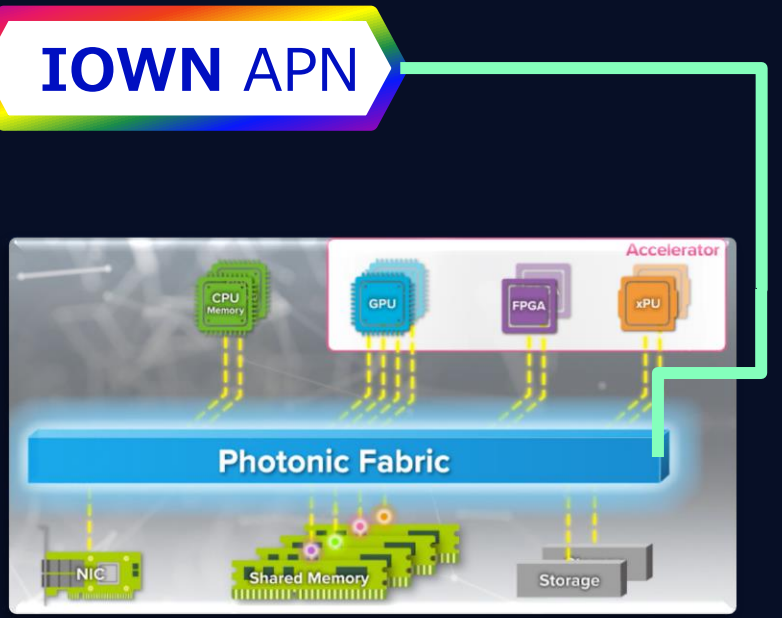
# Use Case: AI Analysis of Numerous Videos



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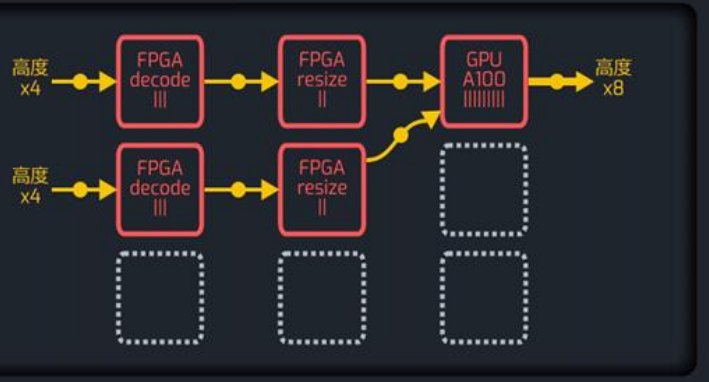
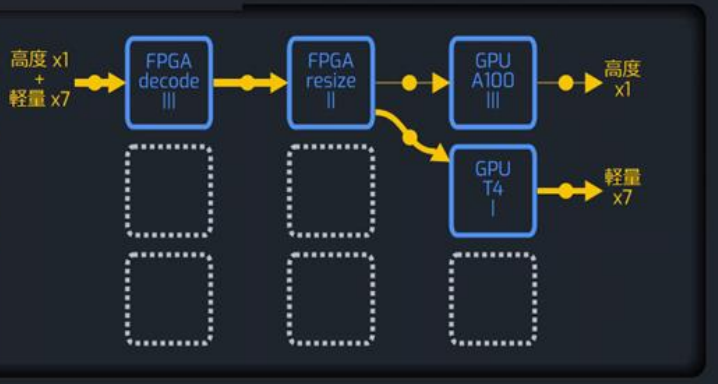
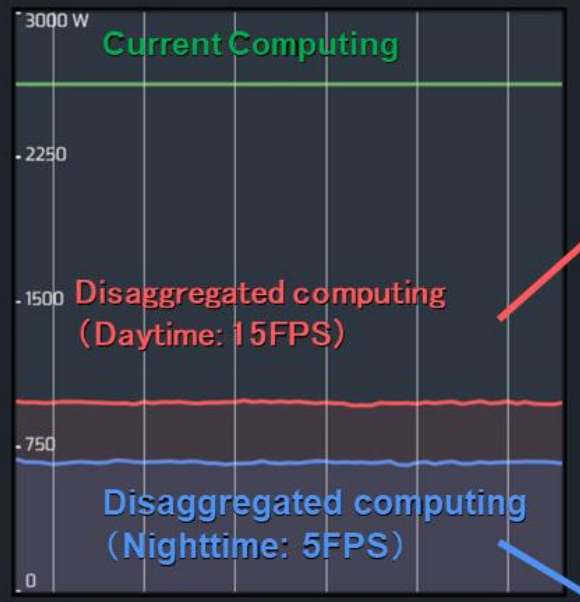
# Power Management Efficiencies

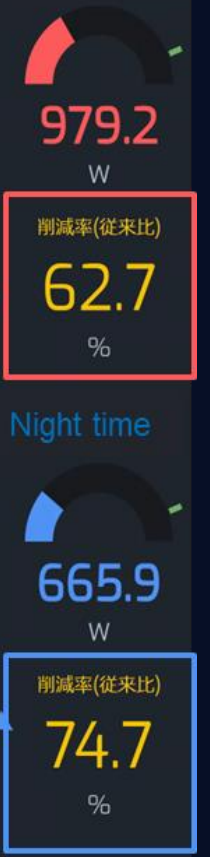
## Day time




## Night time

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# All-Photonics Network (APN)
# with Low Latency and Flexible Deployment

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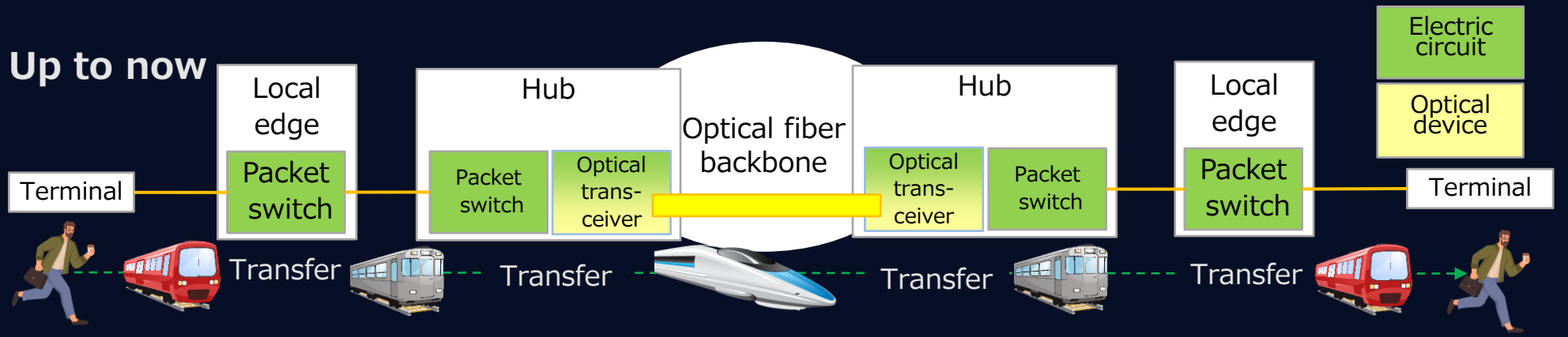
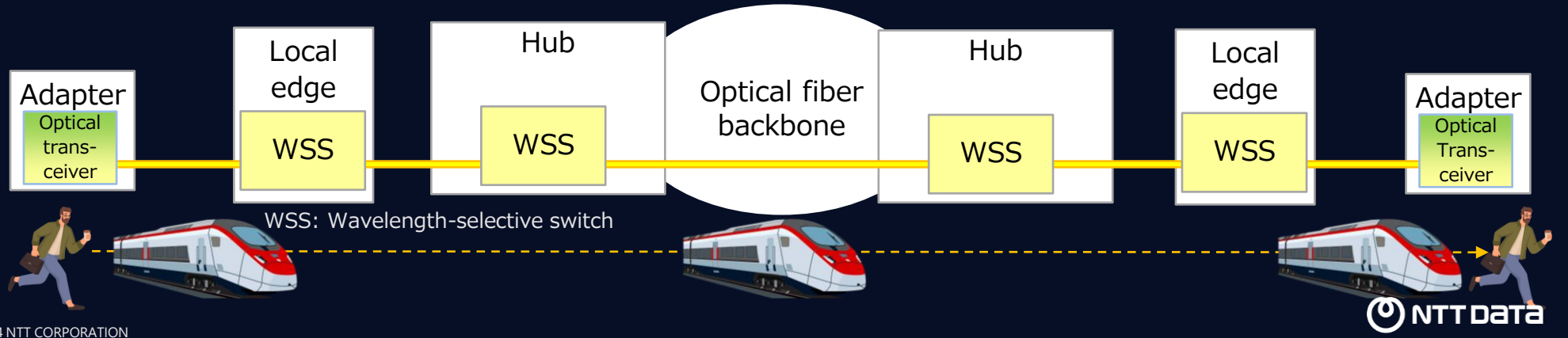
IOWN network:

# All-Photonics Network (APN)




## All-Photonics Network (APN)

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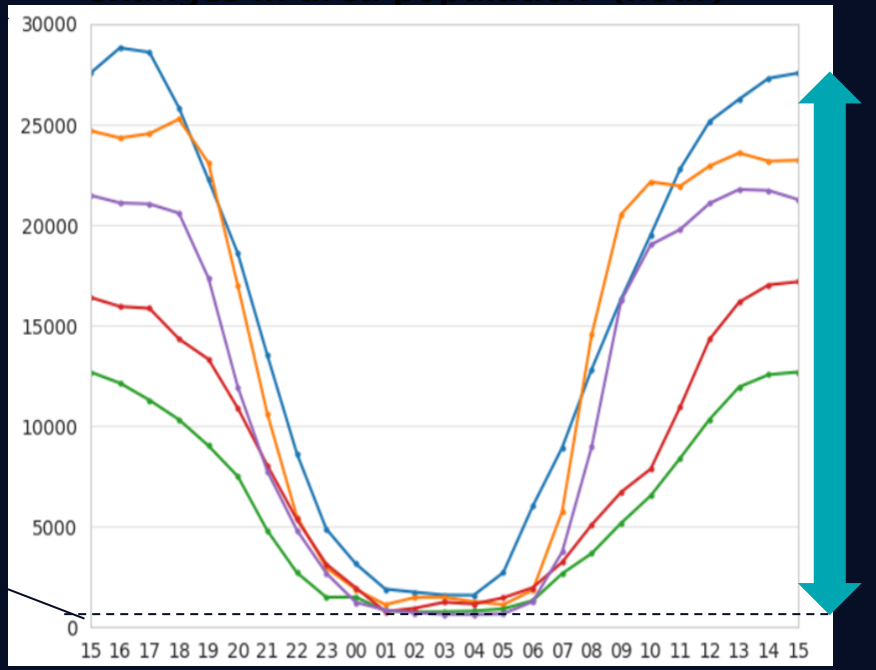
# Elastic Load Balancing

**Dynamic control in response to changing area population**
**→ High energy efficiency**

Service area

Changes in area population（hour）

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# APN and Data Centers Footprints

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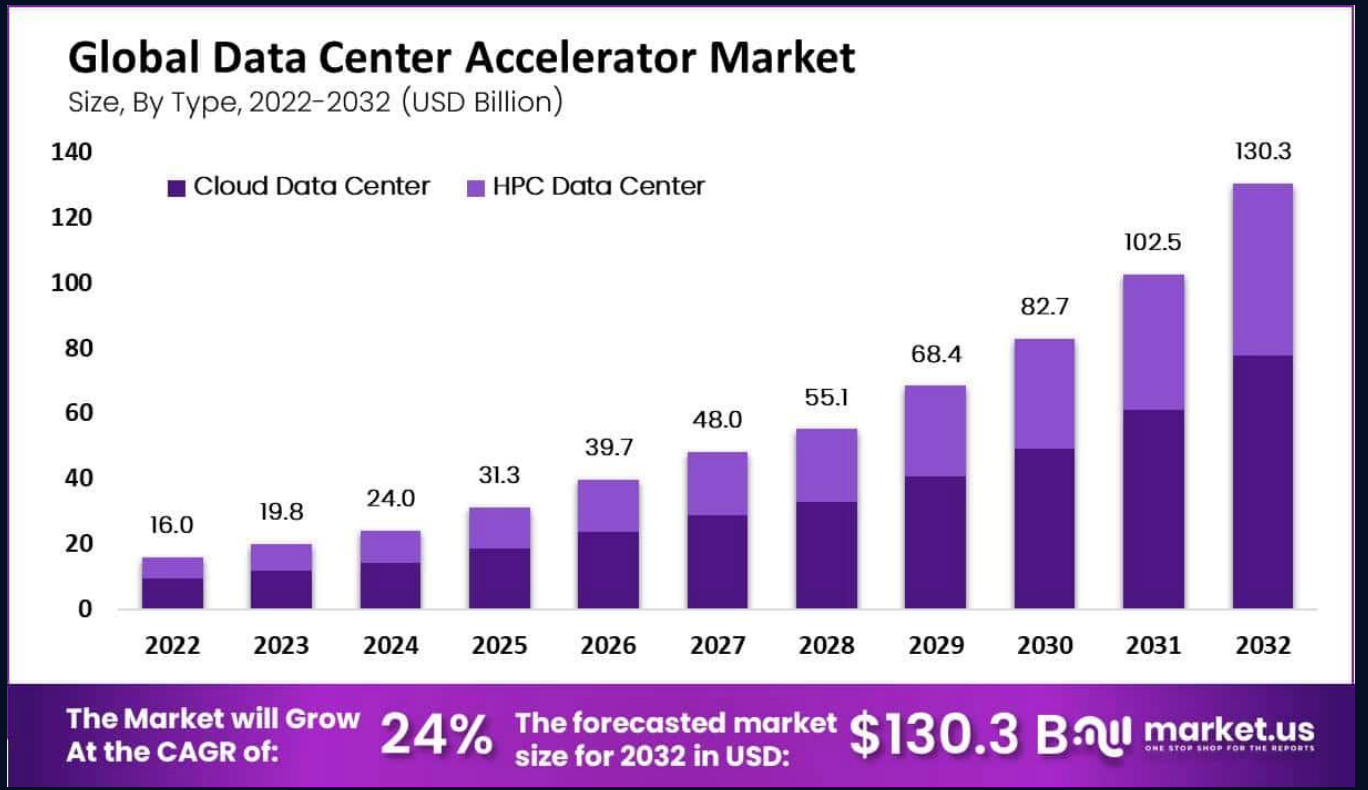
# Data Center Market ~~Growth~~ Boom

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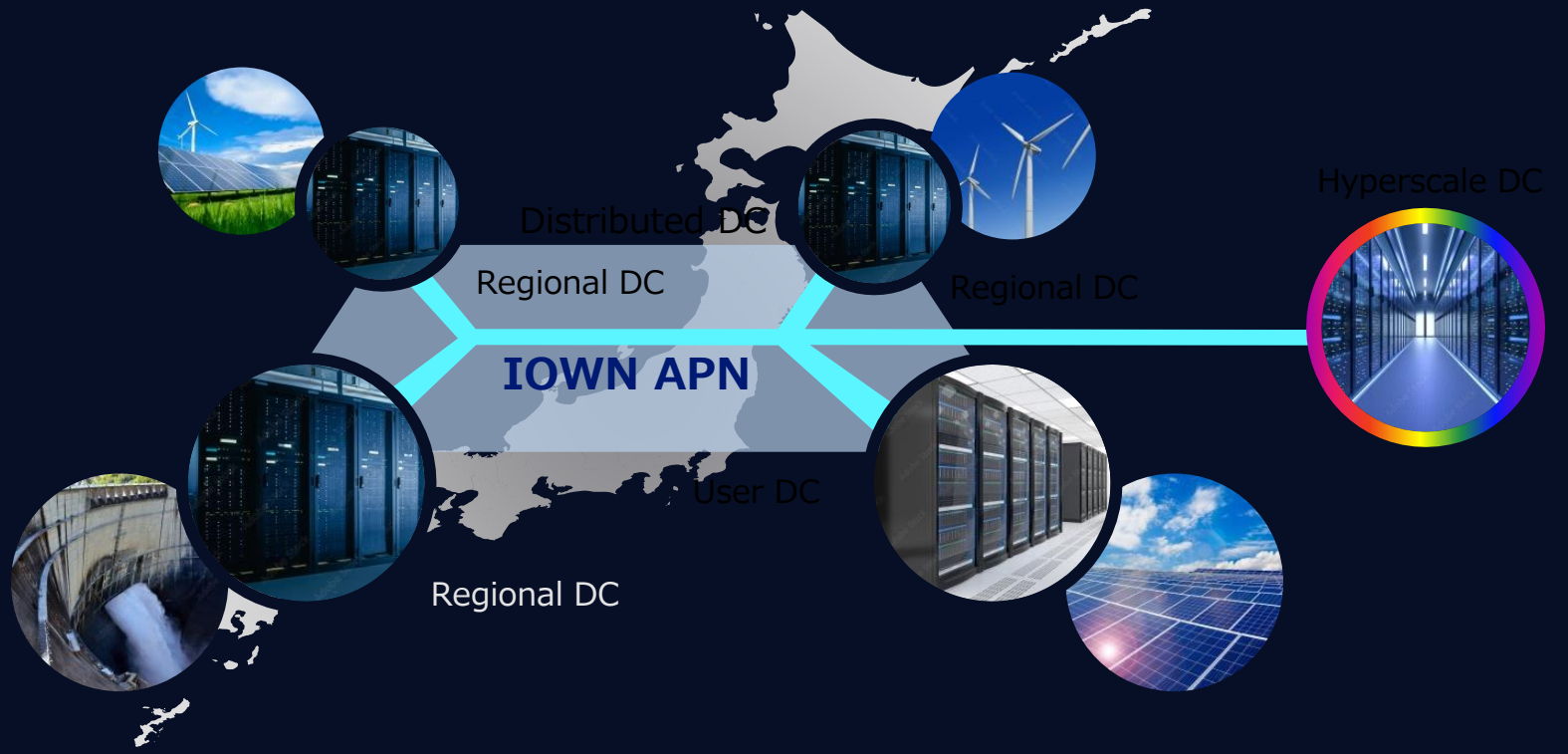
# Inter-datacenter Connection

**Connecting datacenters (DCs) with the APN enables functional distribution and high availability**

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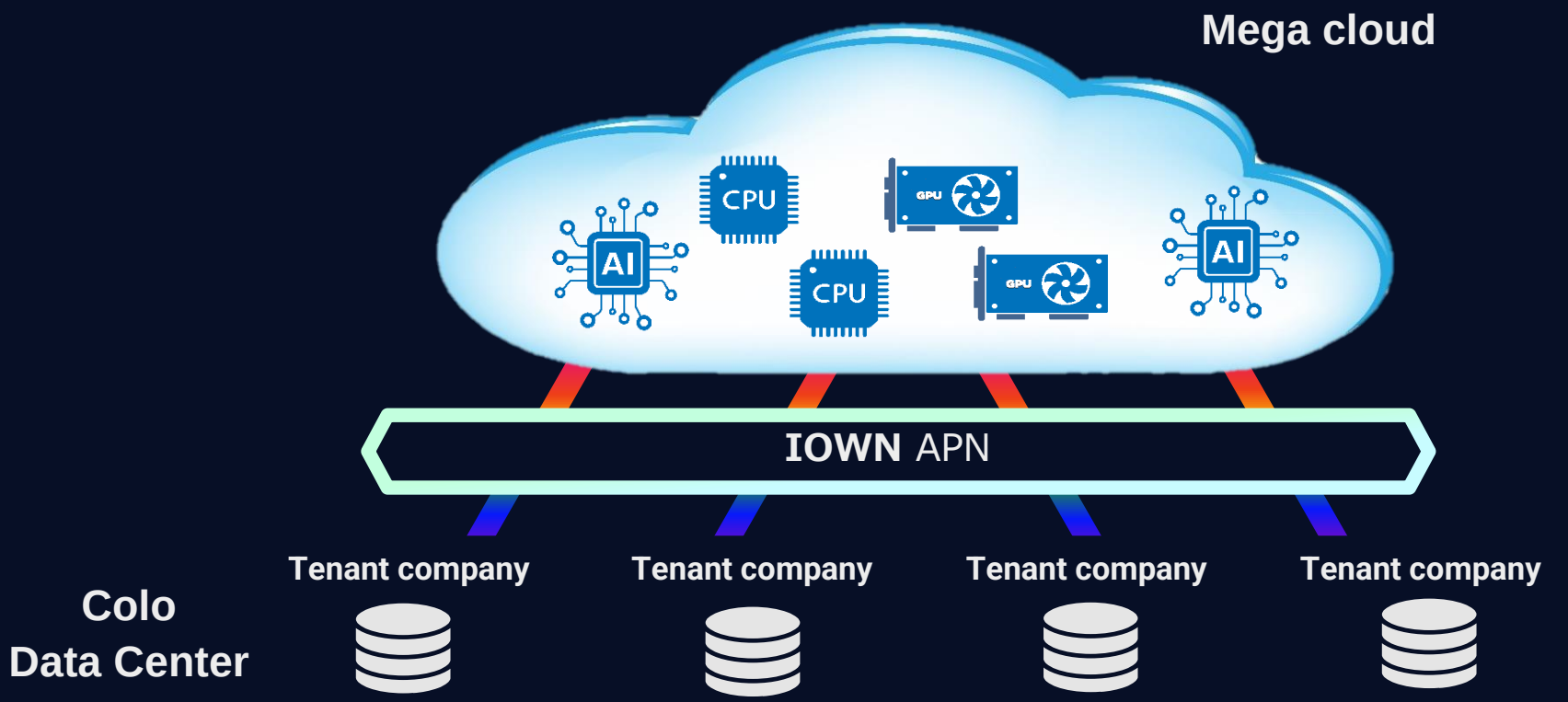
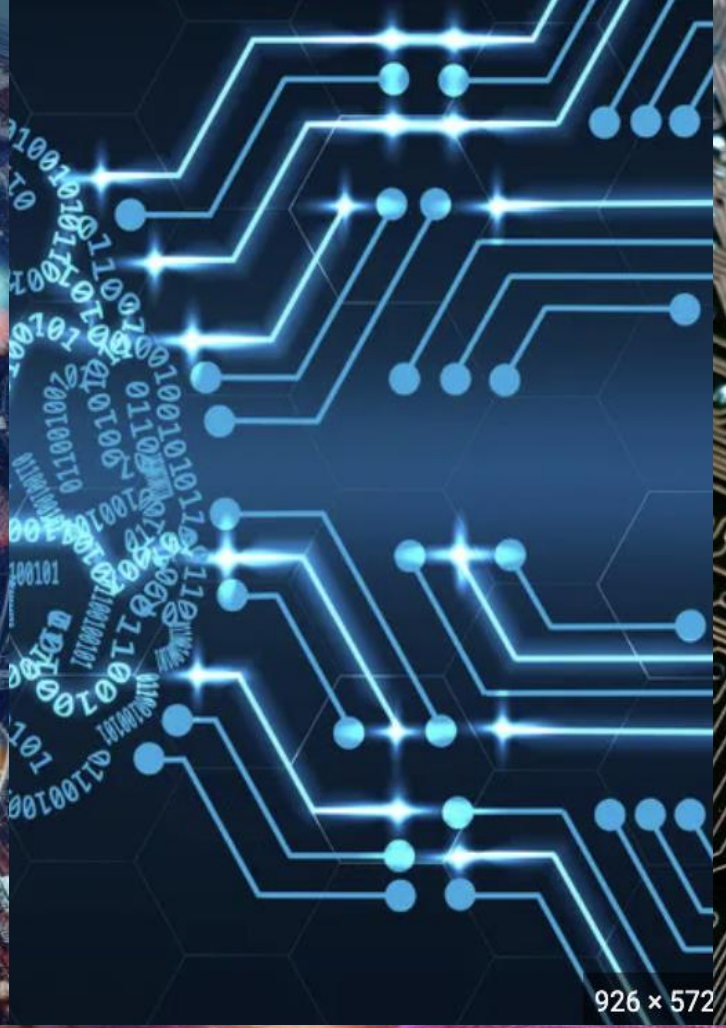
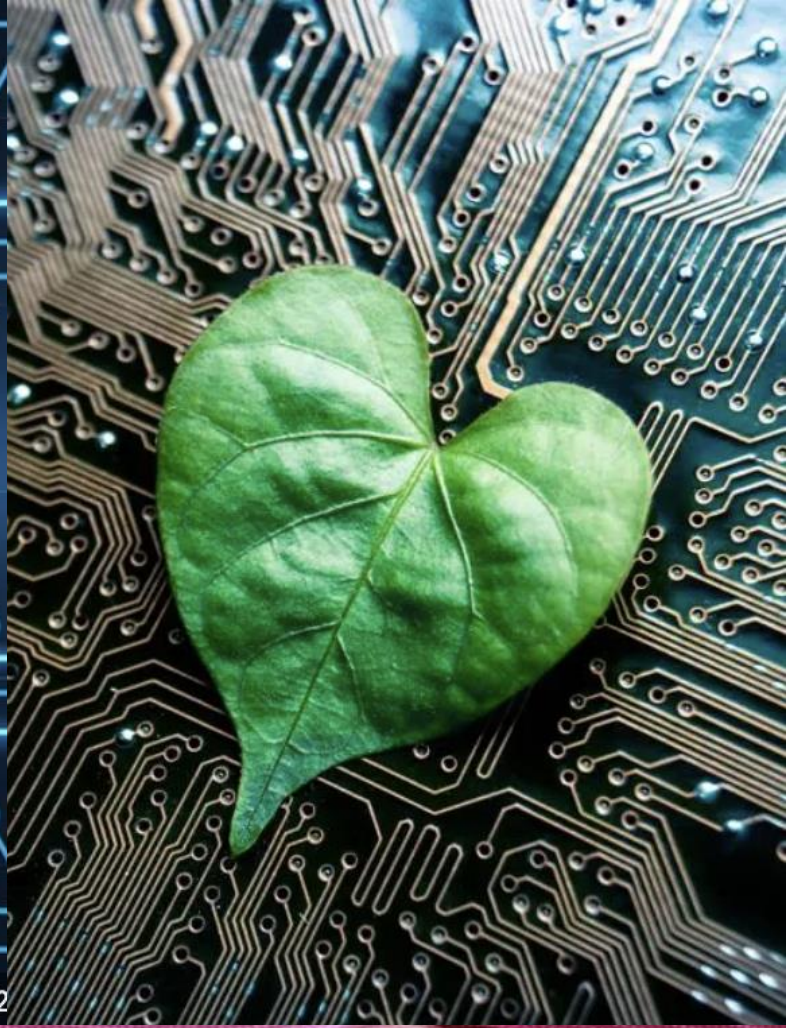
# Hybrid Sovereign Cloud





926 × 572

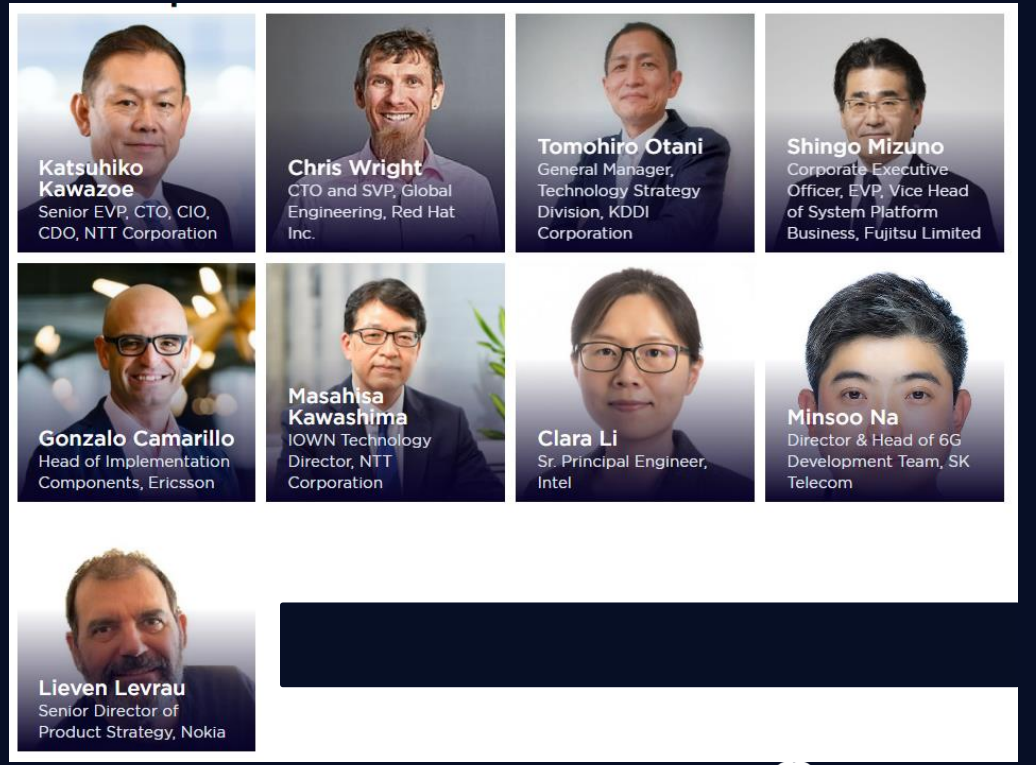


# IOWN Global Forum Session – Tomorrow

## Innovative Optical and Wireless Network for the Evolution of Mobile Networks

**When**: Thursday, 29-February 10am-11:30am
**Where**: Partner Theatre 6, Hall 8.0

IOWN Global Forum's technical leaders present an overview of IOWN Global Forum's Open APN and how this new network will contribute to the evolution of radio access networks (RANs) and multi-access edge computing (MEC).

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# Innovating with Innovative Materials (Particles) of the Future

Rika Nakazawa
rika.nakazawa@global.ntt
LinkedIn: Rika Nakazawa

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# Balaji Krishnan

## CEO & Founder

Displace

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# Up Next

## FWA: Scaling the Success

16:15 - 17:00

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