



# Ultra-Brain Neuromorphic by Material-Device-System Co-Research

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## Grand Challenge and Goal:

Material-Device-System Co-Research can realize Ultra-Brain Neuromorphic Systems with Super-Low Power Consumption, Compact, and High Speed.

Dramatic Reduction of Power Consumption for Big Data Analysis and Data Communication is Core of Carbon Neutral

Created future by this research

**Summary:** Advanced candidate ↓ • Incorporation of others → QKV attention

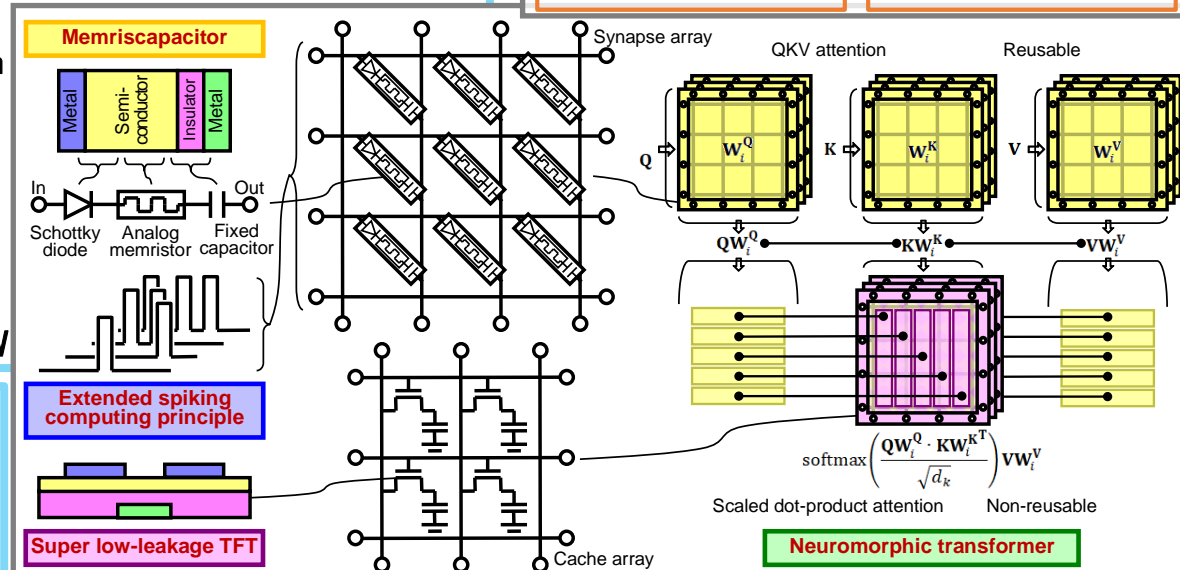
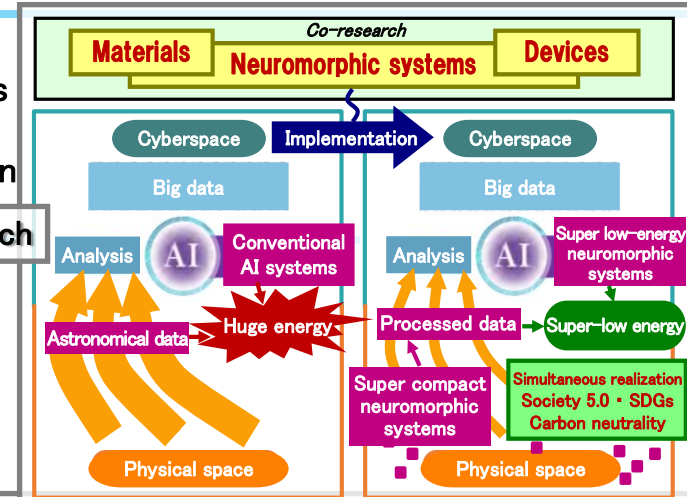
- Memristor = Analog memristor + Capacitor + Schottky ⇒ Dynamic behavior
- Extended spiking principle = Simultaneous use of various parameters • Stochastic
- Super low-leakage TFT = Analog cache → Scaled dot-product attention
- ↓ Best assign of reusable or unnecessary data to effective integration of non and volatile devices

『 Neuromorphic Transformer 』

- Basic research [SSI] • Prototype • Actual verification
  - Device =  $10^5$  : Speed < 10ms : Power < 100pJ/token
- [LSI] • System simulation
  - Device =  $10^{14}$  : Speed < 10ms : Power < 100mJ/token
- Transfer research • Prototype • Actual verification
  - Social implementation • IoT verification
- ◆ Novelty • Originality Co-research → Simple • LSI
  - Resource  $O(n^2) \rightarrow O(1)$  Efficiency 180nm264 → 1540 TOPS/W

## Social Impact:

- AI power consumption ⇒  $\frac{1}{100}$  World Today → 2050
  - Data communication ⇒ 100 power 25PWh → 800 ⇒ 29
- Complete solution to future problem of power consumption  
Society 5.0 & SDGs & Carbon neutral



Neuromorphic transformer by memristors, spiking principle, and super low-leakage TFTs