Integrated Circuits Technologies are still very important for Green or power saving!

1. Green by Integrated Circuits

   Power saving by Microprocessor control for all the human systems

2. Green of Integrated Circuits

   Power saving of Integrated Circuits by Down Scaling of MOSFETs in PC, Data Center, Router, etc.
Question:
How far we can go with downscaling?
Tunneling distance: 3 nm

Atom distance: 0.3 nm

MOSFET operation:

$Lg = 3 \text{ nm?}$

Below this, no one knows future!

Ultimate Limit

Predicted limit now
How far can we go?

**Past** 0.7 times per 3 years

1973年

\[
8\mu m \rightarrow 6\mu m \rightarrow 4\mu m \rightarrow 3\mu m \rightarrow 2\mu m \rightarrow 1.2\mu m \rightarrow 0.8\mu m \rightarrow 0.5\mu m \\
\rightarrow 0.35\mu m \rightarrow 0.25\mu m \rightarrow 180\text{nm} \rightarrow 130\text{nm} \rightarrow 90\text{nm} \rightarrow 65\text{nm} \rightarrow 45\text{nm}
\]

**Now**

In 40 years: 15 generations, Size 1/200, Area 1/40,000

**Future**

\[
32\text{nm} \rightarrow 22\text{nm} \rightarrow 16\text{nm} \rightarrow 11.5\text{nm} \rightarrow 8\text{nm} \rightarrow 5.5\text{nm}? \rightarrow 4\text{nm}? \rightarrow 2.9\text{nm}?
\]

- At least 5.6 generations, for 15 ~ 20 years
- Hopefully 8 generations, for 30 years
Today’s Discussion

What about the future of nanoelectronic devices?
Thank you for your attention!