

# CMOS is dead ... Long live CMOS!

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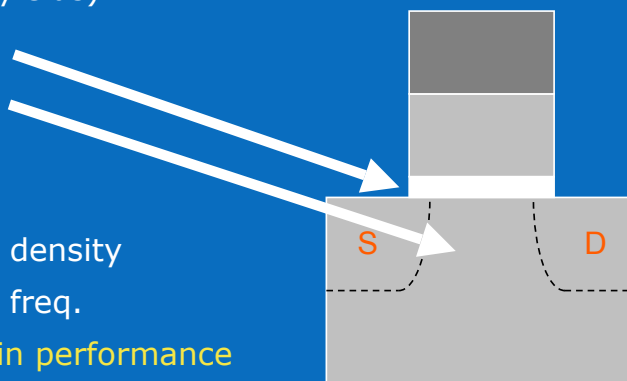
## Past Era: "Simple" CMOS Scaling

Simple scaling

- Linear shrink (+raise yields)
- Thin gate oxide
- Junction engineering
- Reduce voltage

Lasted about 10 years

- ~10x improvement in density
- ~10x improvement in freq.
- >>10x improvement in performance



High Volume Manufacturing (intro year)	1995	1997	1999	2001
Technology Node	0.35 um	0.25 um	0.18 um	0.13 um
Integration Capacity	10's million			1 Billion

4/10/07 Hot Chips CMOS panel



# Current Era: Materials + CMOS Scaling

## Simple scaling

- Linear shrink (+ raise yields)
- Thin gate oxide
- Junction engineering
- Reduce voltage

## Materials + scaling

- Complex shrink (+raise yields)
- High K/Metal gates
- Strain engineering
- Slowed voltage (+manage power)

Still has life left !

### Intel first to implement

	1995	1997	1999	2001	2003	2005	2007	
High Volume Manufacturing (intro year)								
Technology Node	0.35 um	0.25 um	0.18 um	0.13 um	90 nm	65 nm	45 nm	
Integration Capacity	10's million			1 Billion			8 Billion	

4/10/07 Hot Chips CMOS panel

# Future Era: Devices + Materials + CMOS Scaling

## Materials + scaling

- Complex shrink (+raise yields)
- High K/Metal gates
- Strain engineering
- Slowed voltage (+manage power)

## Device + materials + scaling

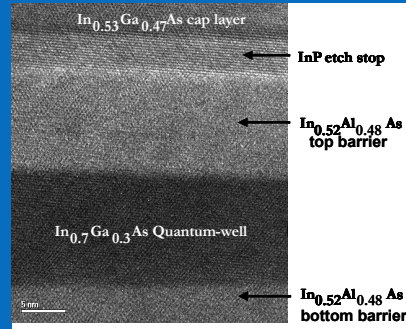
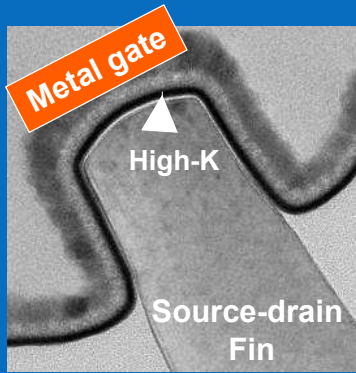
- Complex shrink (+raise yields)
- High K/Metal gates
- Strain engineering
- Slowed voltage
- New devices to manage power

Still has life left !

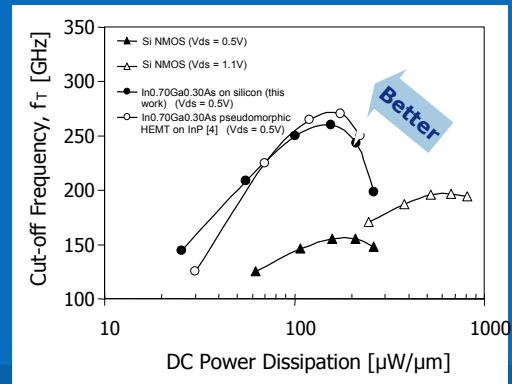
Expect ~10 further years !

	1995	1997	1999	2001	2003	2005	2007	
High Volume Manufacturing (intro year)								
Technology Node	0.35 um	0.25 um	0.18 um	0.13 um	90 nm	65 nm	45 nm	~2017
Integration Capacity	10's million			1 Billion			8 Billion	below 10 nm 100's Billions

4/10/07 Hot Chips CMOS panel



- Trigate – demonstrated to below 10nm
  - Better electrostatics
  - Less intrinsic variation
  - Allows voltage reduction
- III-V quantum well devices
  - Much lower operating voltage
  - New ways to optimize devices
  - Many hard problems



## Summary

- Simple scaling was never simple
- The current era of materials + scaling still has life
- New CMOS devices demonstrated can take us near 2020
- Beyond that we can't tell but clever people are working on it today
- Moore's Law will continue
- No need to mourn the past, the future is still bright !