

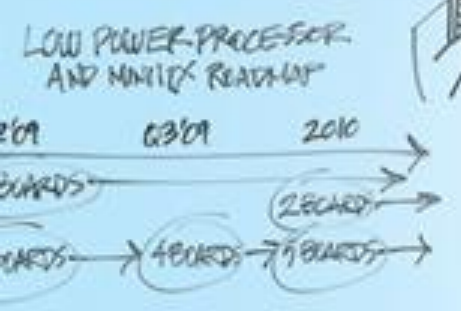
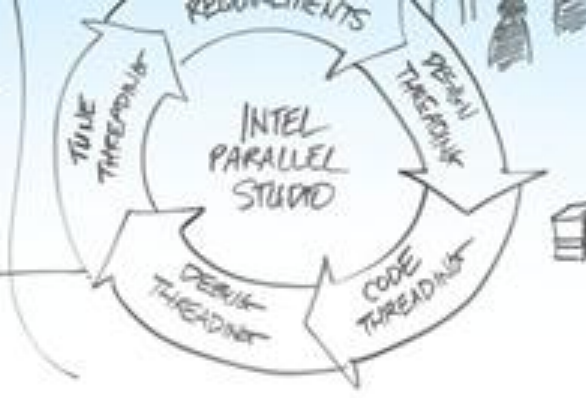


2005

- 5.1M BOPS
- 8 RACKS
- 126 SERVERS
- 240 SQ FT
- 48 KW

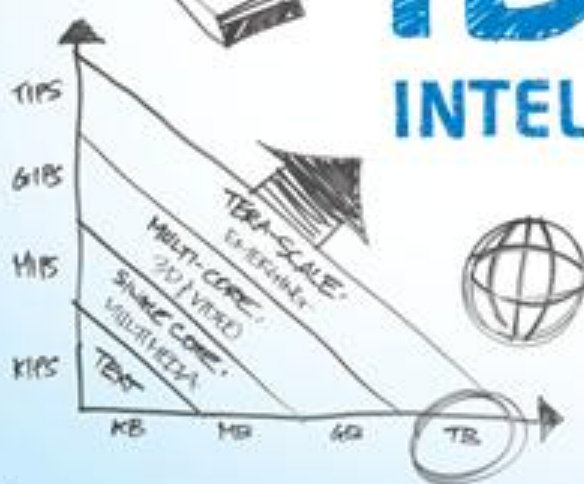
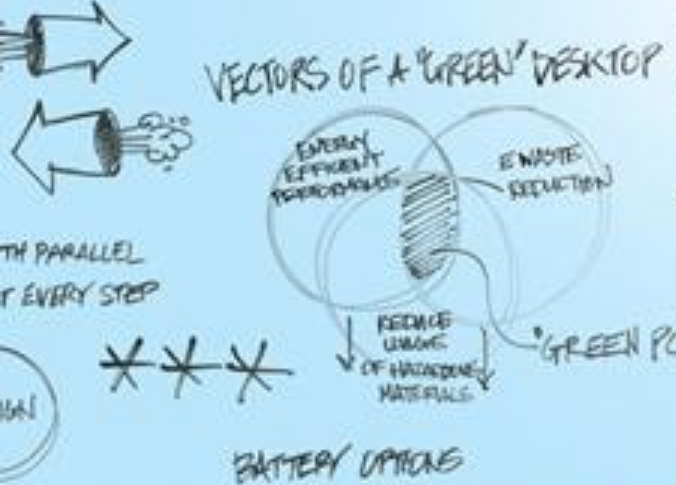
2009

- 5.1M BOPS
- 1 RACK
- 17 SERVERS
- 40 SQ FT
- 6 KW



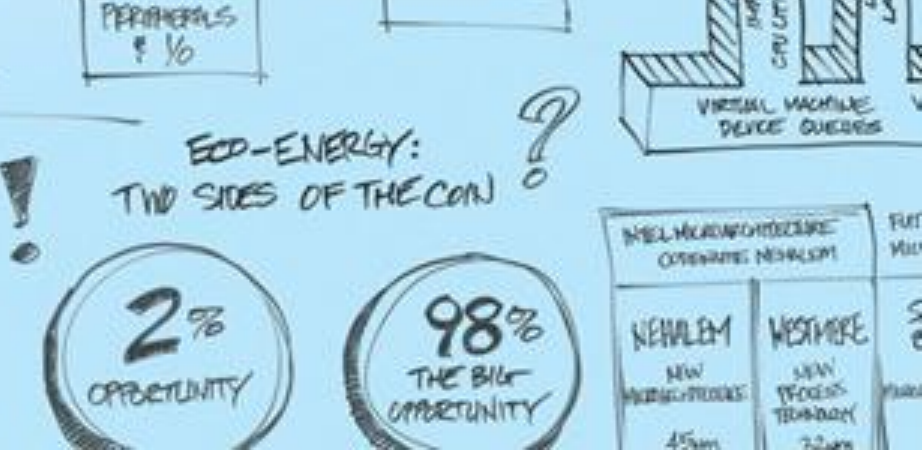
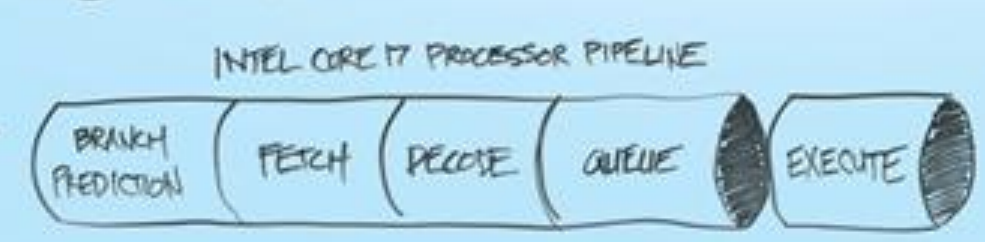
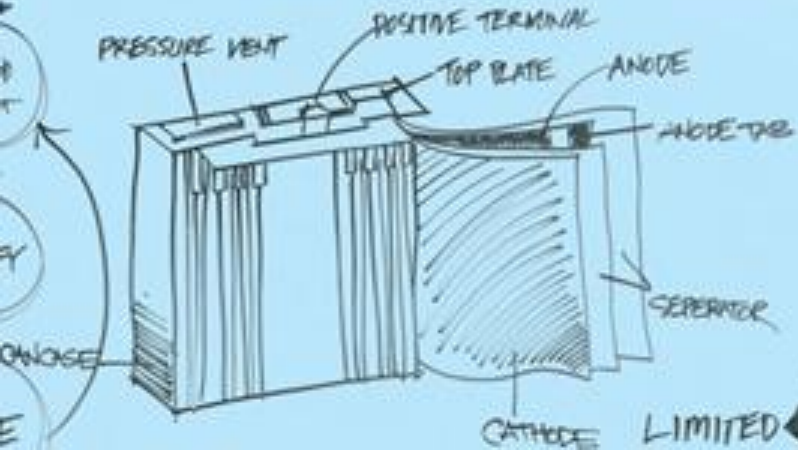
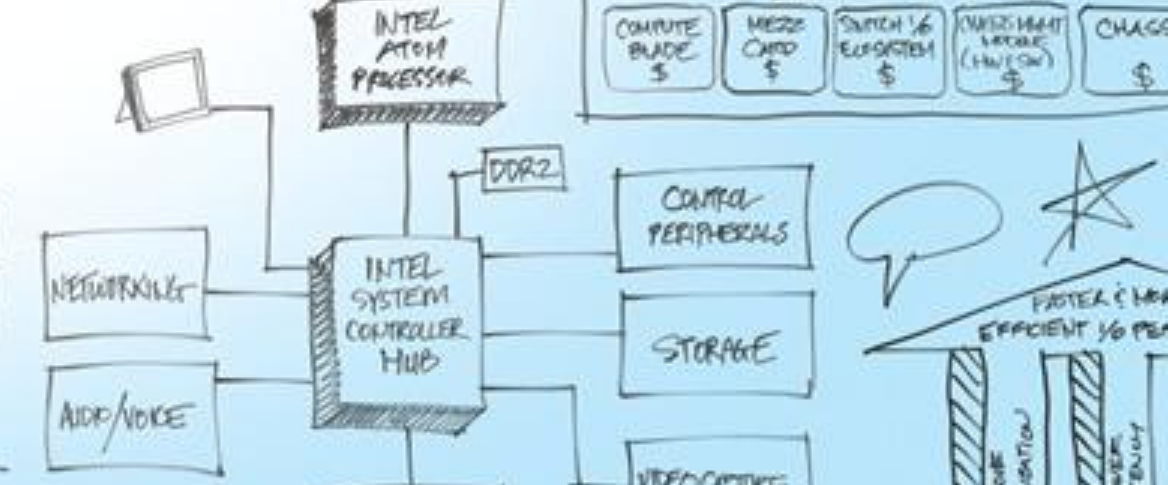
IDF2009

INTEL DEVELOPER FORUM



STORAGE: HARD DISK DRIVE OPTIONS

2.5" HDD	1.8" HDD
110-250 GB	60-120 GB
7.95 mm	5 mm
DUAL	SINGLE
1x	2x2 SAME CAPACITY
CAPACITY	
THICKNESS	
PLATTER	
COST	



INTEL MICROPROCESSOR OPERATING NEARLY

NEHALEM	WESTMERE
NEW MICROPROCESSORS	NEW PROCESSOR TECHNOLOGY
45nm	32nm

6 KW
BOTTOM LINE
ENERGY COSTS
87%
ENERGY SAVINGS
\$53K



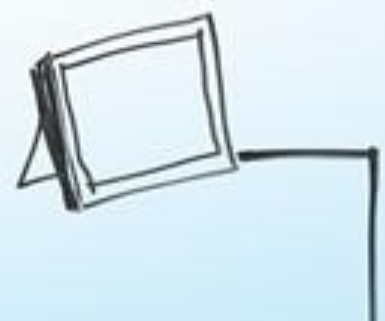
BOB BAKER

Senior Vice President
General Manager,

Technology and Manufacturing Group



7-CORE:
VIDEO
TERA-SCALE:
EMERGING





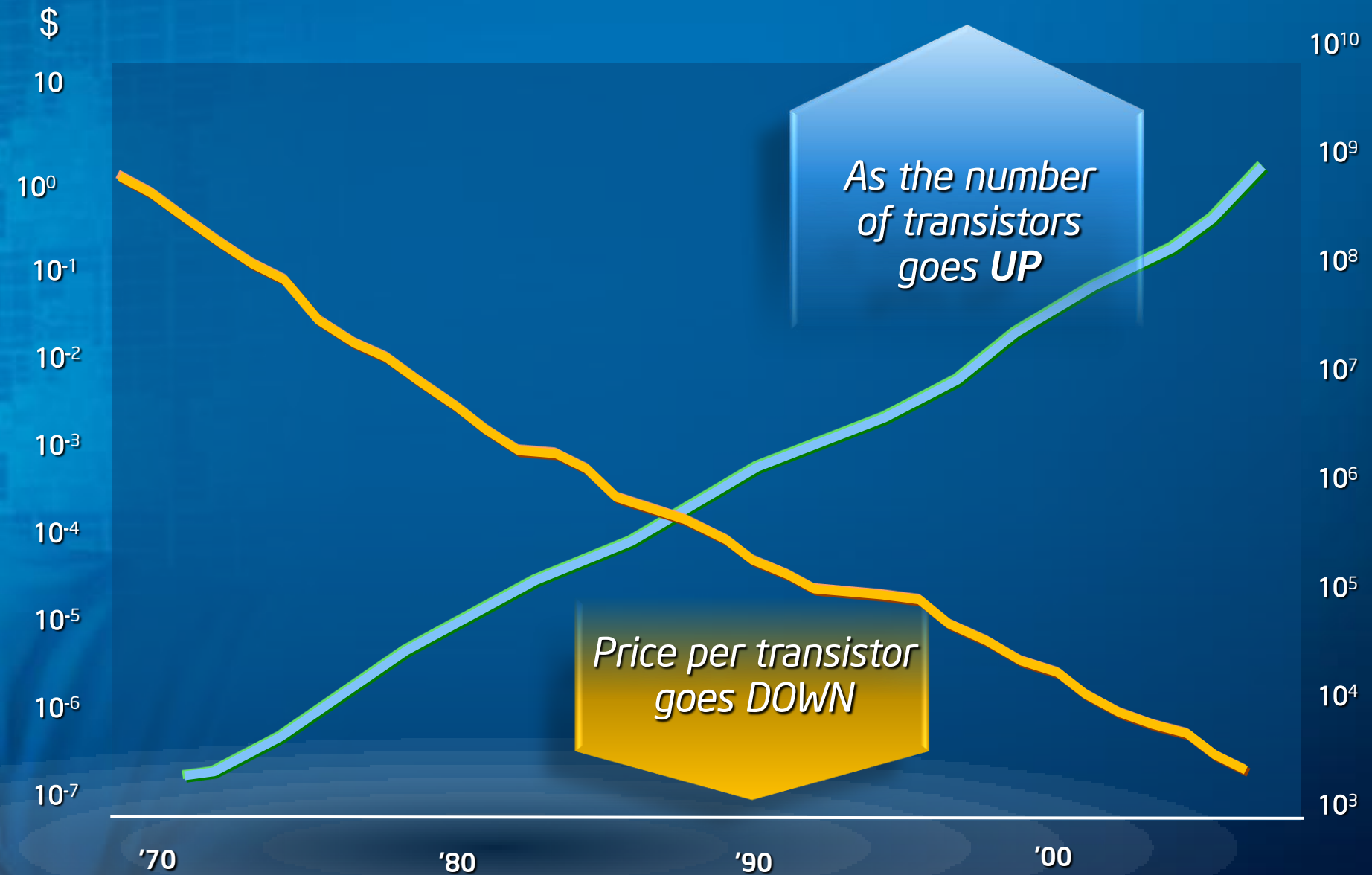
Silicon Leadership: Delivering Innovation

Relentless Pursuit of Moore's Law

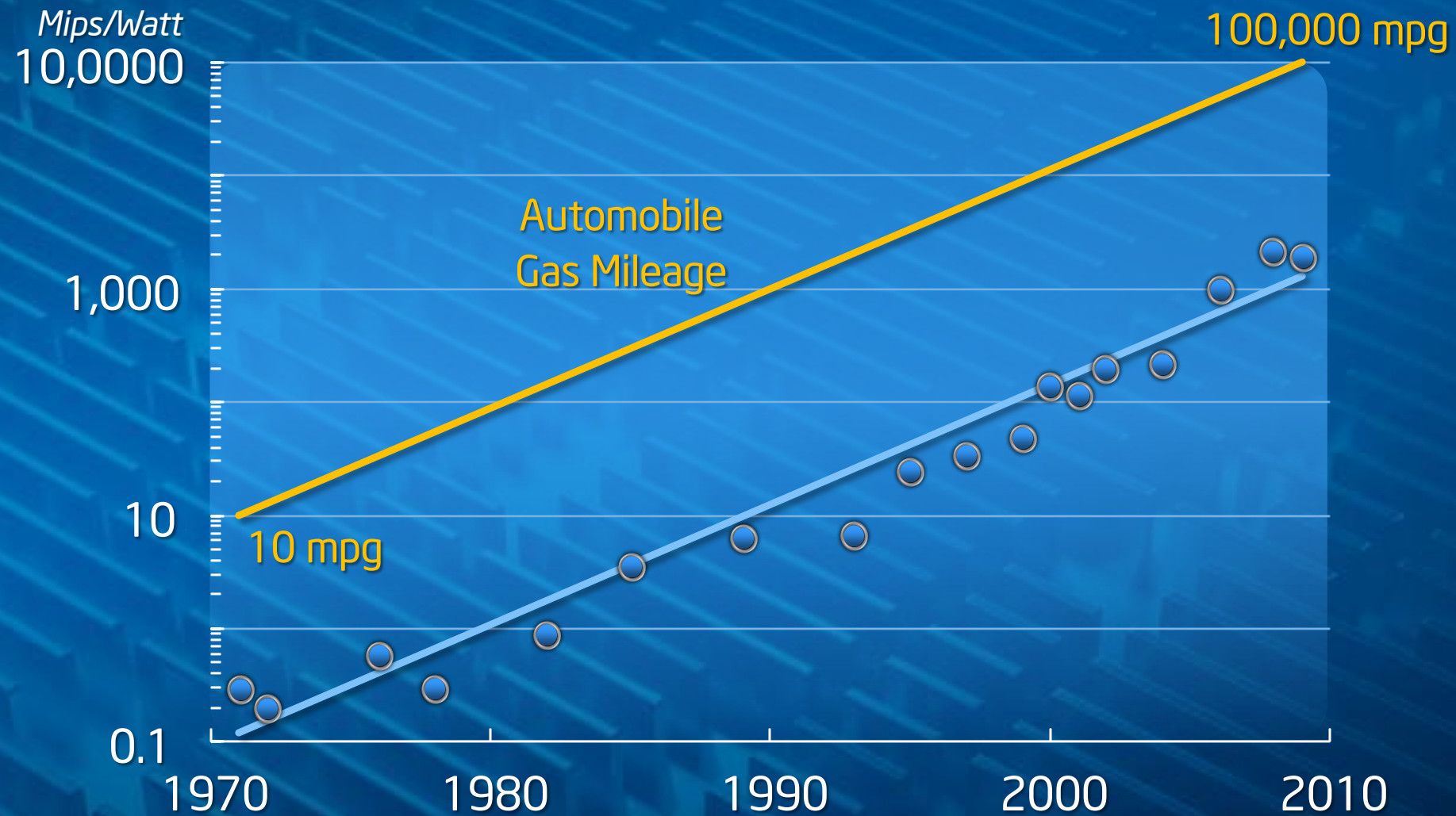
Innovations in Silicon Technology

Extending Leadership for New Opportunities

Moore's Law Still Drives Intel

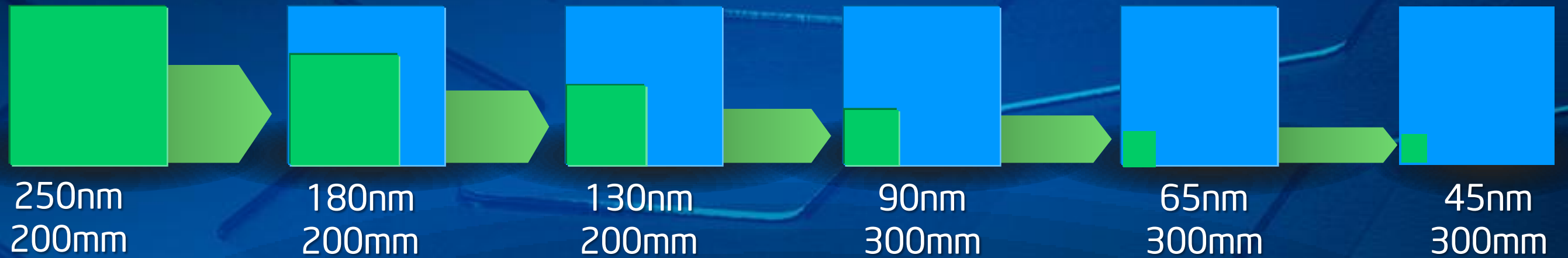


Intel CPU Mips per Watt Trend



If gas mileage improved as fast as CPU Mips/Watt,
we'd have cars today with ~100,000 mpg

The Fundamental Driver of Cost and Innovation



Cost Reduction
Same circuitry
half the space

OR

**Architectural
Innovation**
Twice the
circuitry in the
same space

=

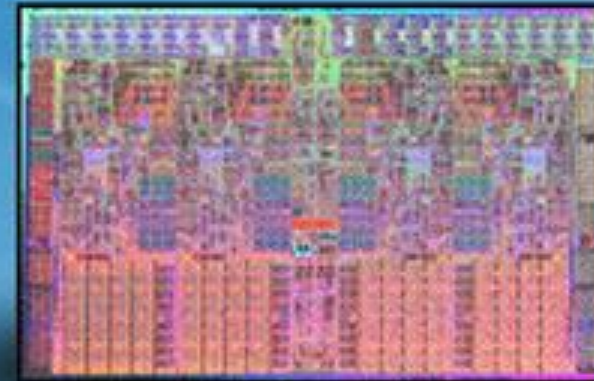
Option to design
for optimal
performance/cost

45 nm Products Across the Board

Single Core

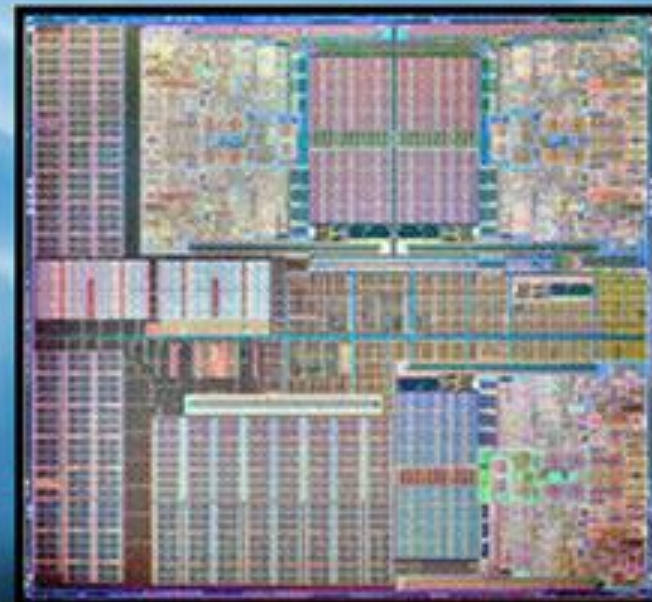


Dual Core

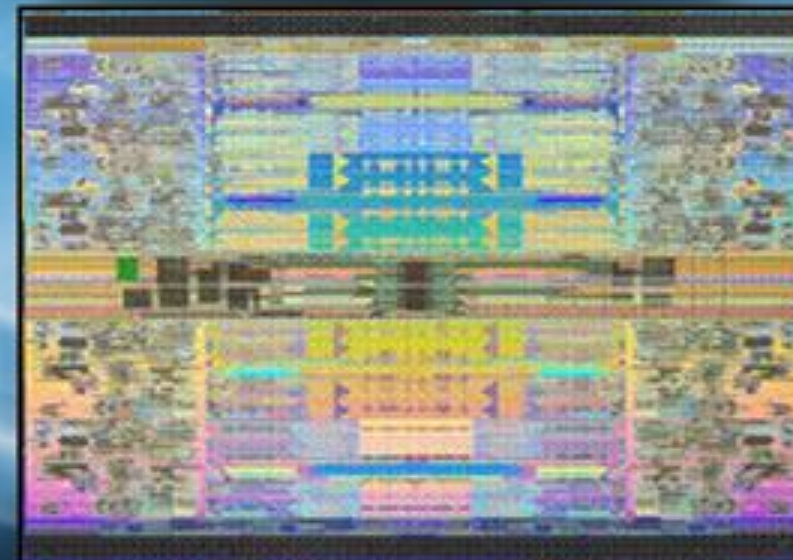


Quad Core

6 Core



8 Core



Innovation-Enabled Technology Pipeline:

Researchers are Moving on to Investigation of Novel Technology Options

65nm
2005

45nm
2007

32nm
2009

22nm
2011

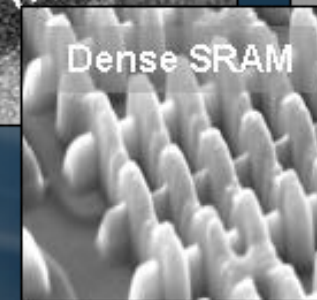
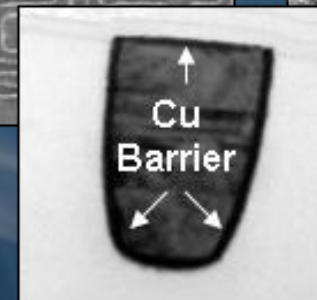
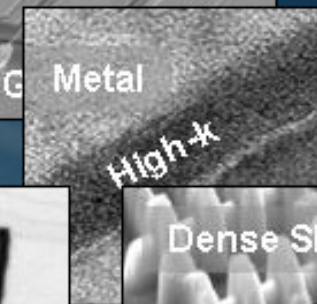
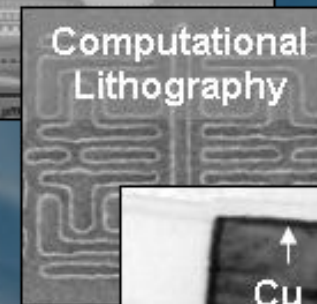
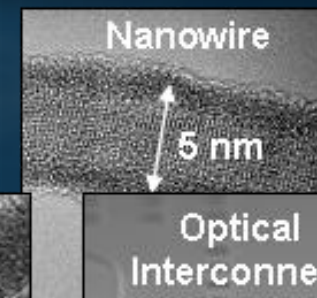
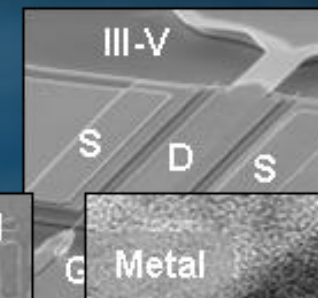
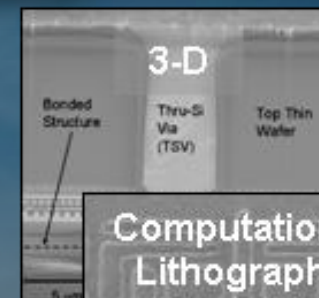
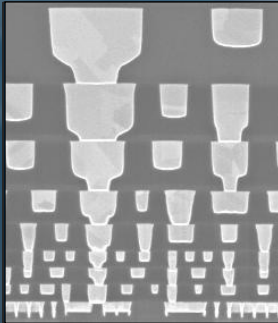
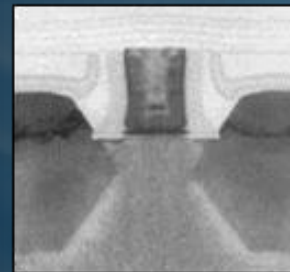
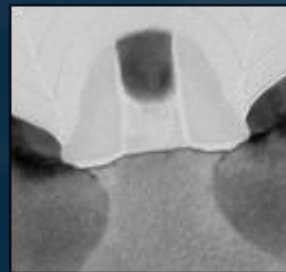
15nm
2013

<15nm
2015 +

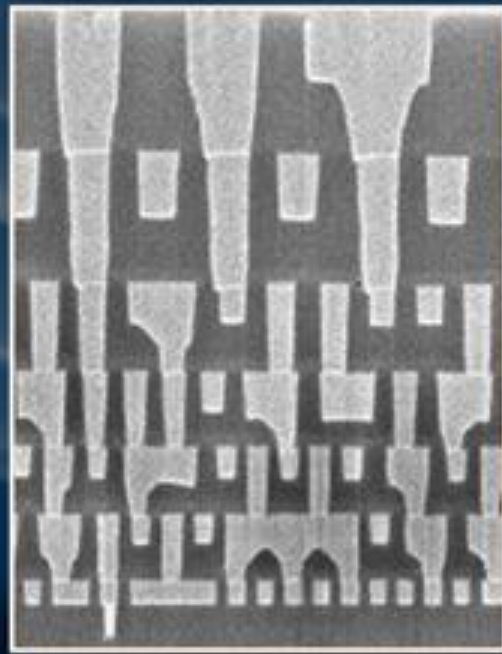
Manufacturing

Development

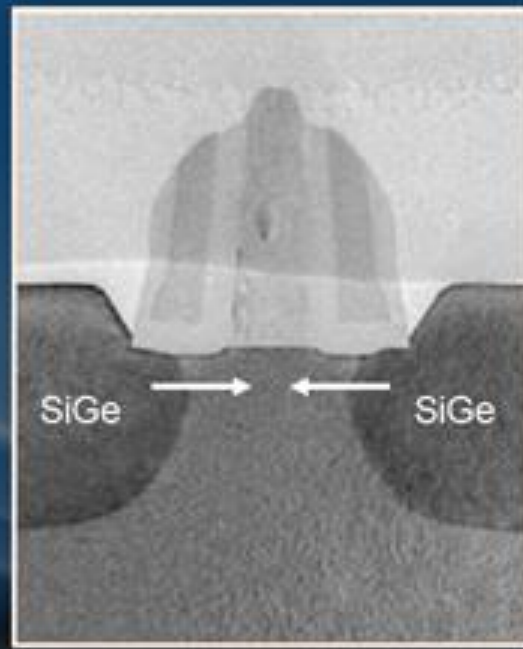
Research



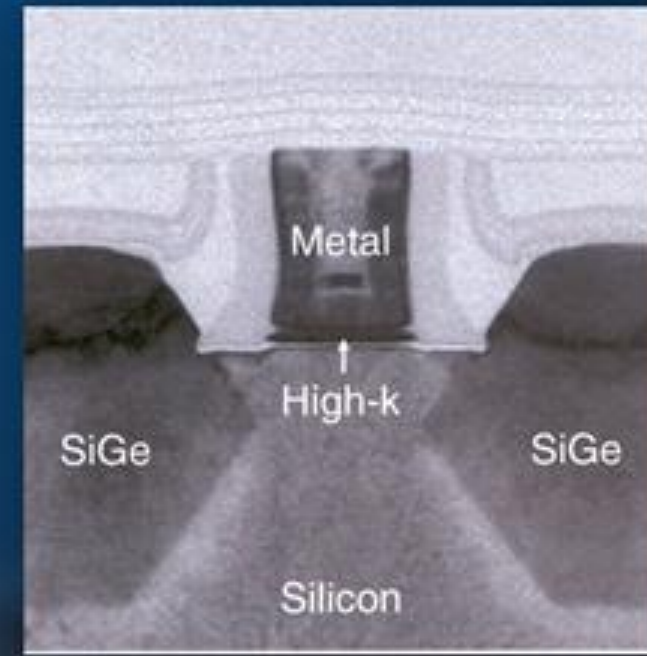
The New Era of Scaling



Copper + Low-k



Strained Silicon



High-k + Metal Gate

Modern CMOS scaling is as much about material innovation as dimensional scaling

III-V

The Periodic Table of the Elements

1 H Hydrogen 1.00794																	2 He Helium 4.003						
3 Li Lithium 6.941	4 Be Beryllium 9.012182																	5 B Boron 10.811	6 C Carbon 12.0107	7 N Nitrogen 14.00674	8 O Oxygen 15.9994	9 F Fluorine 18.9984032	10 Ne Neon 20.1797
11 Na Sodium 22.989770	12 Mg Magnesium 24.3050																	13 Al Aluminum 26.981538	14 Si Silicon 28.0855	15 P Phosphorus 30.973761	16 S Sulfur 32.066	17 Cl Chlorine 35.4527	18 Ar Argon 39.948
19 K Potassium 39.0983	20 Ca Calcium 40.078	21 Sc Scandium 44.955910	22 Ti Titanium 47.867	23 V Vanadium 50.9415	24 Cr Chromium 51.9961	25 Mn Manganese 54.938044	26 Fe Iron 55.845	27 Co Cobalt 58.933200	28 Ni Nickel 58.6934	29 Cu Copper 63.546	30 Zn Zinc 65.39	31 Ga Gallium 69.723	32 Ge Germanium 72.61	33 As Arsenic 74.92160	34 Se Selenium 78.96	35 Br Bromine 79.904	36 Kr Krypton 83.80						
37 Rb Rubidium 85.4678	38 Sr Strontium 87.62	39 Y Yttrium 88.90585	40 Zr Zirconium 91.224	41 Nb Niobium 92.90638	42 Mo Molybdenum 95.94	43 Tc Technetium (98)	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.90550	46 Pd Palladium 106.42	47 Ag Silver 107.8682	48 Cd Cadmium 112.411	49 In Indium 114.818	50 Sn Tin 118.710	51 Sb Antimony 121.760	52 Te Tellurium 127.60	53 I Iodine 126.90447	54 Xe Xenon 131.29						
55 Cs Cesium 132.90545	56 Ba Barium 137.327	57 La Lanthanum 138.9055	72 Hf Hafnium 178.49	73 Ta Tantalum 180.9479	74 W Tungsten 183.84	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.217	78 Pt Platinum 195.078	79 Au Gold 196.96655	80 Hg Mercury 200.59	81 Tl Thallium 204.3833	82 Pb Lead 207.2	83 Bi Bismuth 208.98038	84 Po Polonium (209)	85 At Astatine (210)	86 Rn Radon (222)						
87 Fr Francium (223)	88 Ra Radium (226)	89 Ac Actinium (227)	104 Rf Rutherfordium (261)	105 Db Dubnium (262)	106 Sg Seaborgium (263)	107 Bh Bohrium (264)	108 Hs Hassium (265)	109 Mt Meitnerium (266)	110 Ds Darmstadtium (269)	111 Rg Roentgenium (272)	112 Cn Copernicium (277)	113 Nh Nihonium	114 Fl Flerovium										
58 Ce Cerium 140.116	59 Pr Praseodymium 140.90765	60 Nd Neodymium 144.24	61 Pm Promethium (145)	62 Sm Samarium 150.36	63 Eu Europium 151.964	64 Gd Gadolinium 157.25	65 Tb Terbium 158.92534	66 Dy Dysprosium 162.50	67 Ho Holmium 164.93032	68 Er Erbium 167.26	69 Tm Thulium 168.93421	70 Yb Ytterbium 173.04	71 Lu Lutetium 174.967										
90 Th Thorium 232.0381	91 Pa Protactinium 231.03588	92 U Uranium 238.0289	93 Np Neptunium (237)	94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Einsteinium (252)	100 Fm Fermium (257)	101 Md Mendelevium (258)	102 No Nobelium (259)	103 Lr Lawrencium (262)										



Jesús A. del Alamo

Home Site Map Contact



Home

Team

Research

Teaching

Brief Bio

Publications

In the News

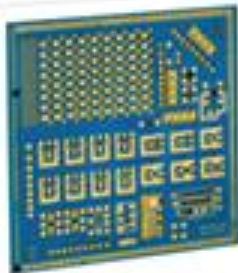
Contact



Jesús del Alamo is Donner Professor, MacVicar Faculty Fellow and Professor of Electrical Engineering in the Department of Electrical Engineering and Computer Science Massachusetts Institute of Technology.

Prof. del Alamo leads a research program on Si and compound semiconductor transistor technologies for RF, microwave and millimeter wave applications. His students have recently fabricated nanometer-scale transistors with world record high frequency operation. Prof. del Alamo is also investigating the use of III-V compound semiconductors to develop a new generation of deeply scaled transistors for future digital applications. His goal is to extend Moore's law using III-V semiconductors. *

Prof. del Alamo is also engaged in exploring the technology and pedagogy of on-site laboratories ("Labs") for science and engineering education. His team has developed laboratory set ups for electrical engineering education that have been accessed by thousands of students from around the world. *



After Silicon

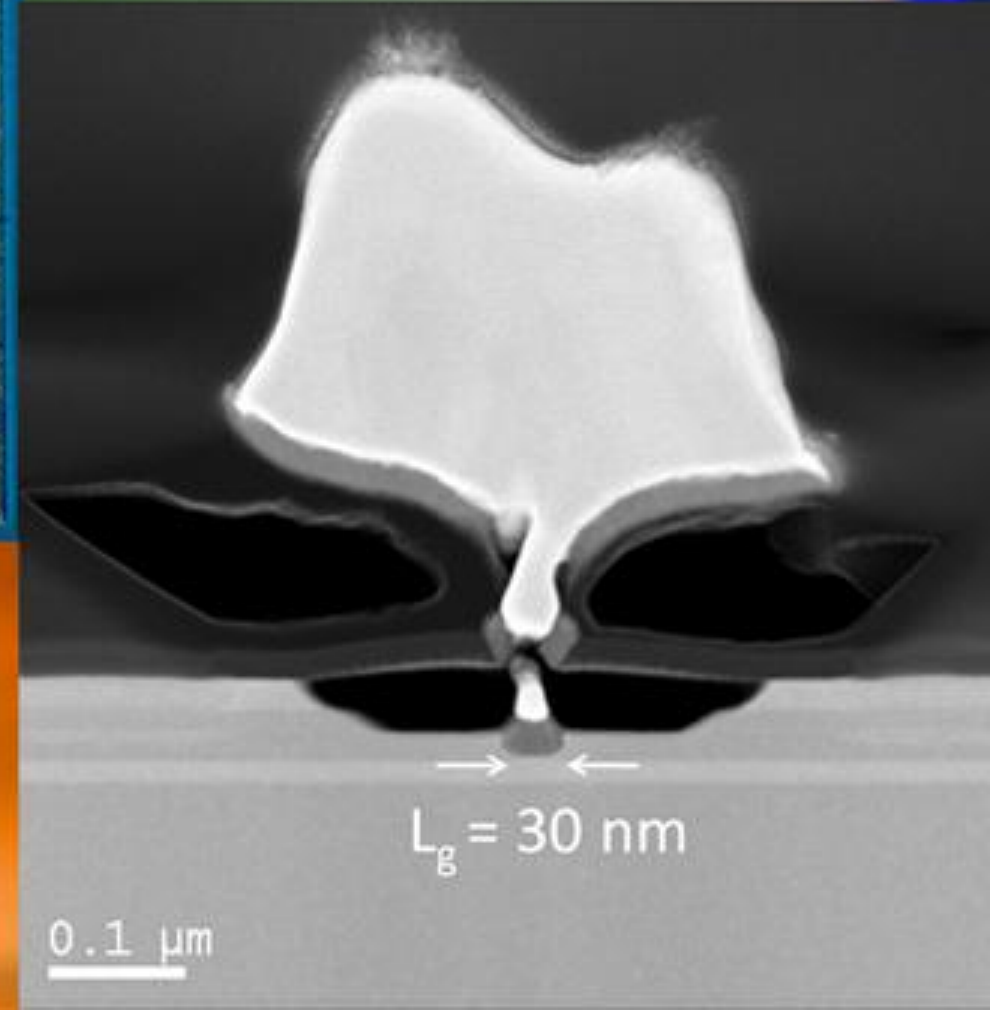
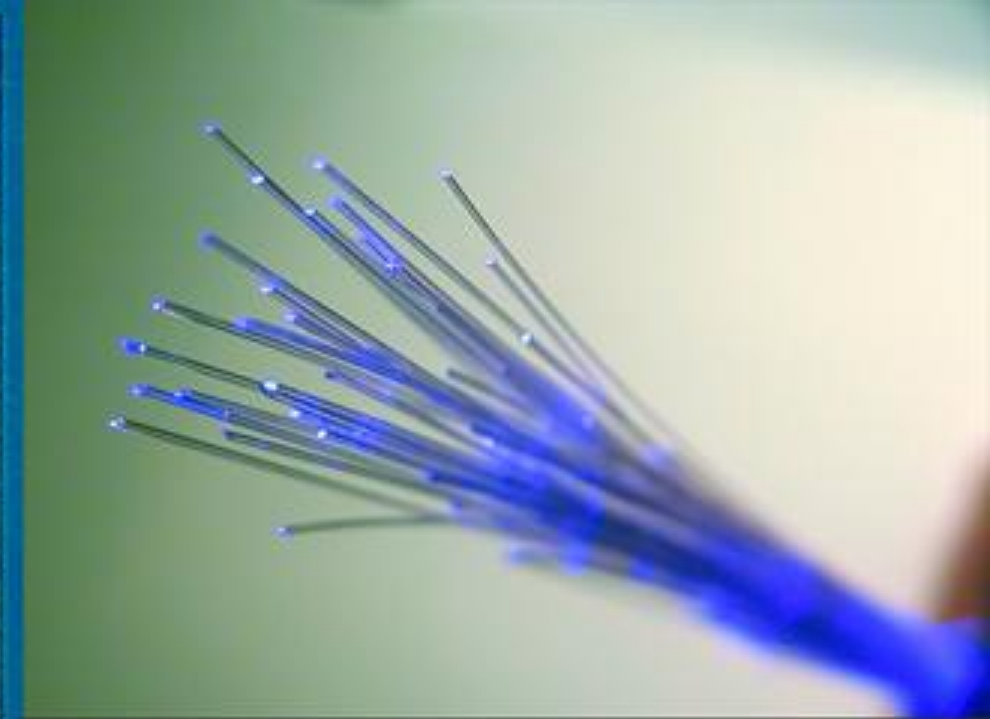
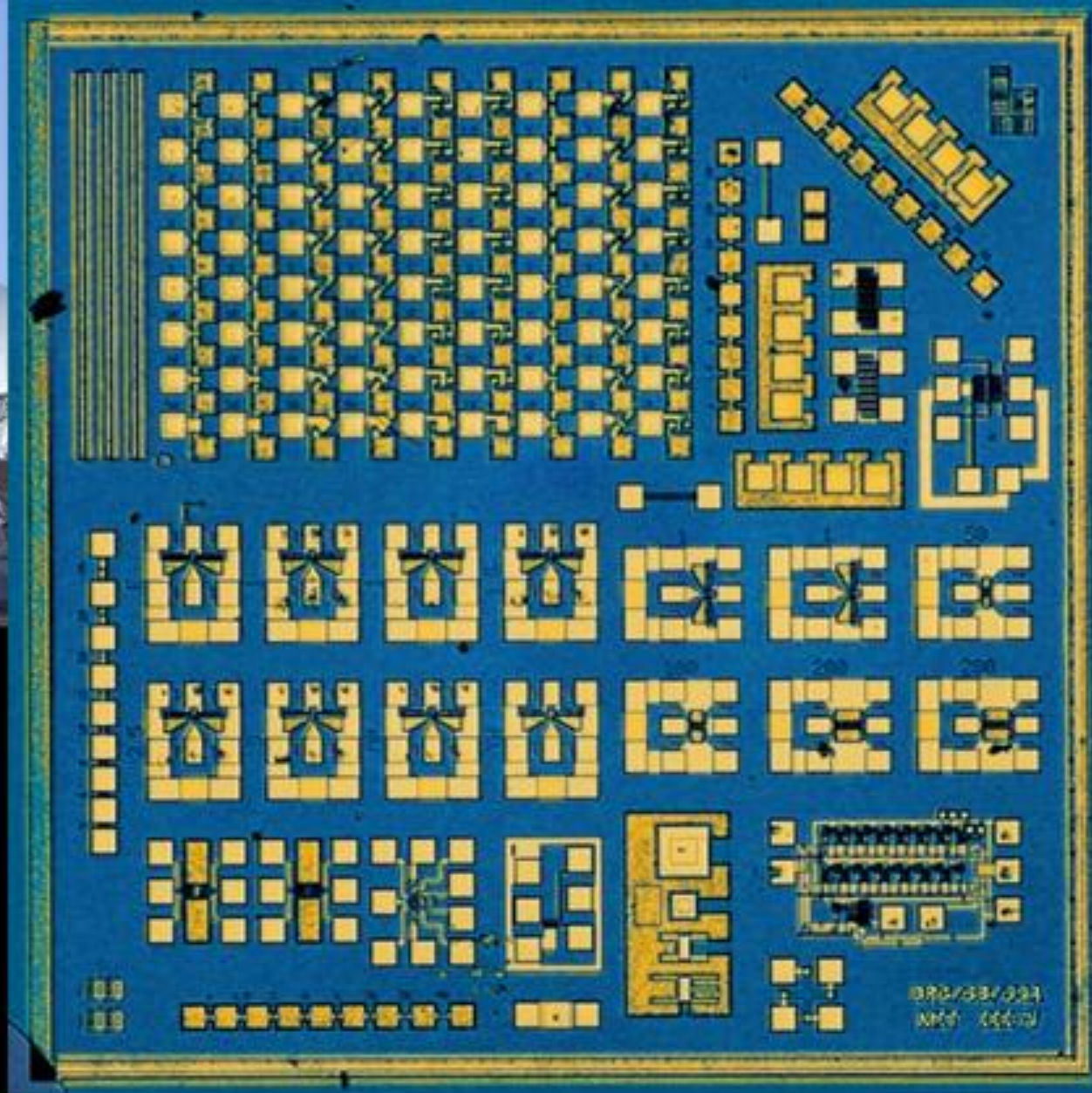
MIT | MTL | EECS

Professor Jesus del Alamo

Professor of Electrical Engineering

Donner Professor, MacVicar Faculty Fellow
Department of Electrical Engineering
and Computer Science

Massachusetts Institute of Technology



IDF2009
INTEL DEVELOPER FORUM

Continuing Moore's Law

Scaling Enables Lower Cost and Higher Capability

Opportunities to Extend Moore's Law

Researchers Doing Innovative Work



Silicon Leadership: Delivering Innovation

Relentless Pursuit of Moore's Law

Innovations in Silicon Technology

Extending Leadership for New Opportunities

On-Time 2 Year Cycles

130 nm
2001

90 nm
2003

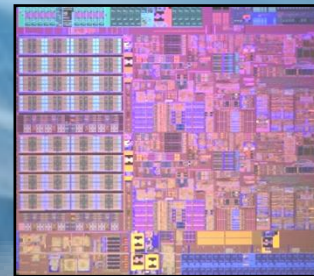
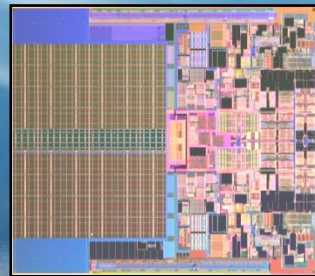
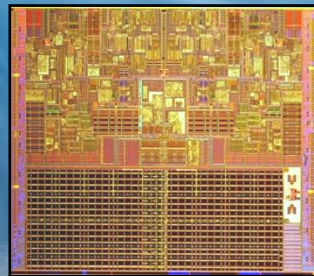
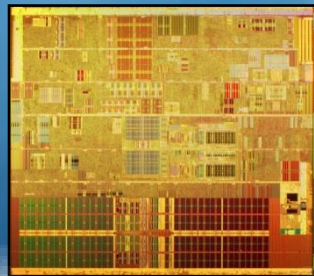
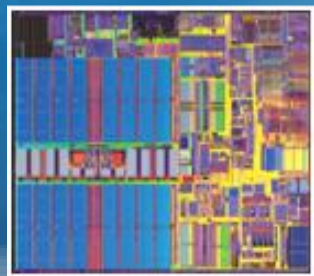
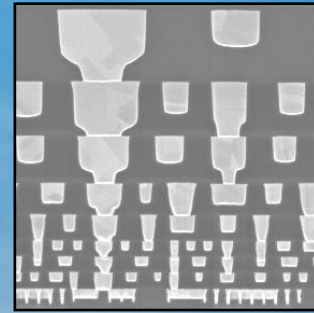
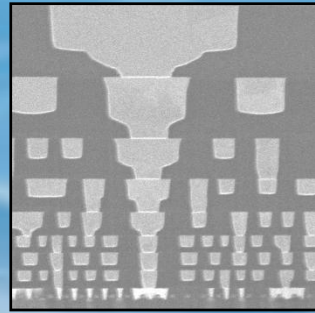
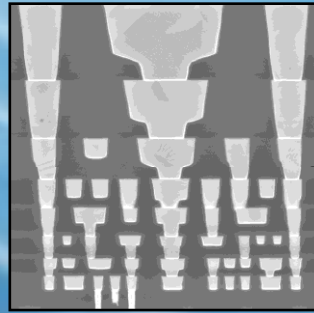
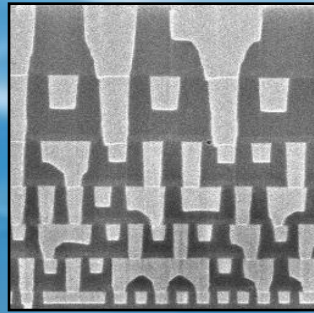
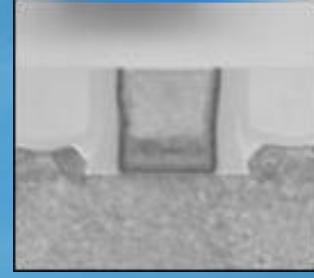
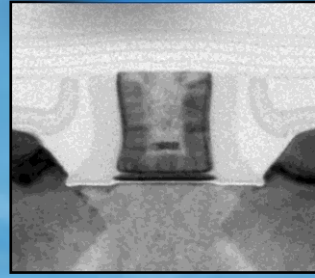
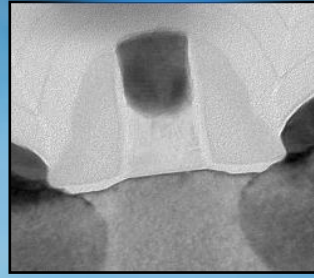
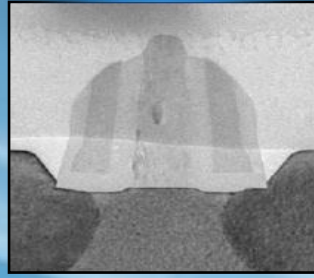
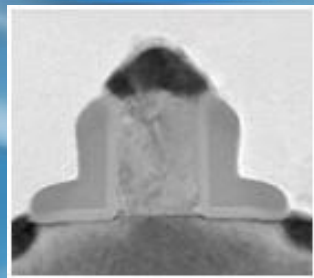
65 nm
2005

45 nm
2007

32 nm
2009

22 nm
2011

15 nm
2013



projected

projected

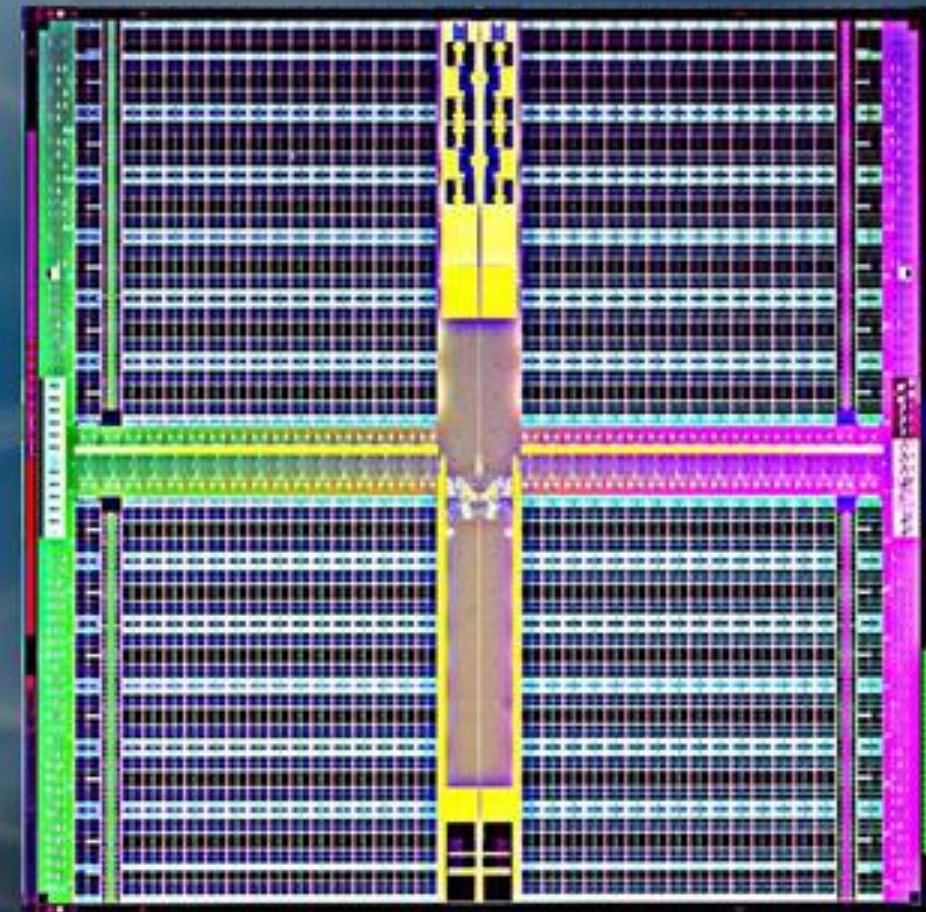
32nm - Extending Technology Leadership

Industry-leading features:

- 2nd generation high-k/metal gate transistors
- 4th generation strained silicon
- Highest reported drive currents
- 0.7x pitch scaling enables 50% area reduction

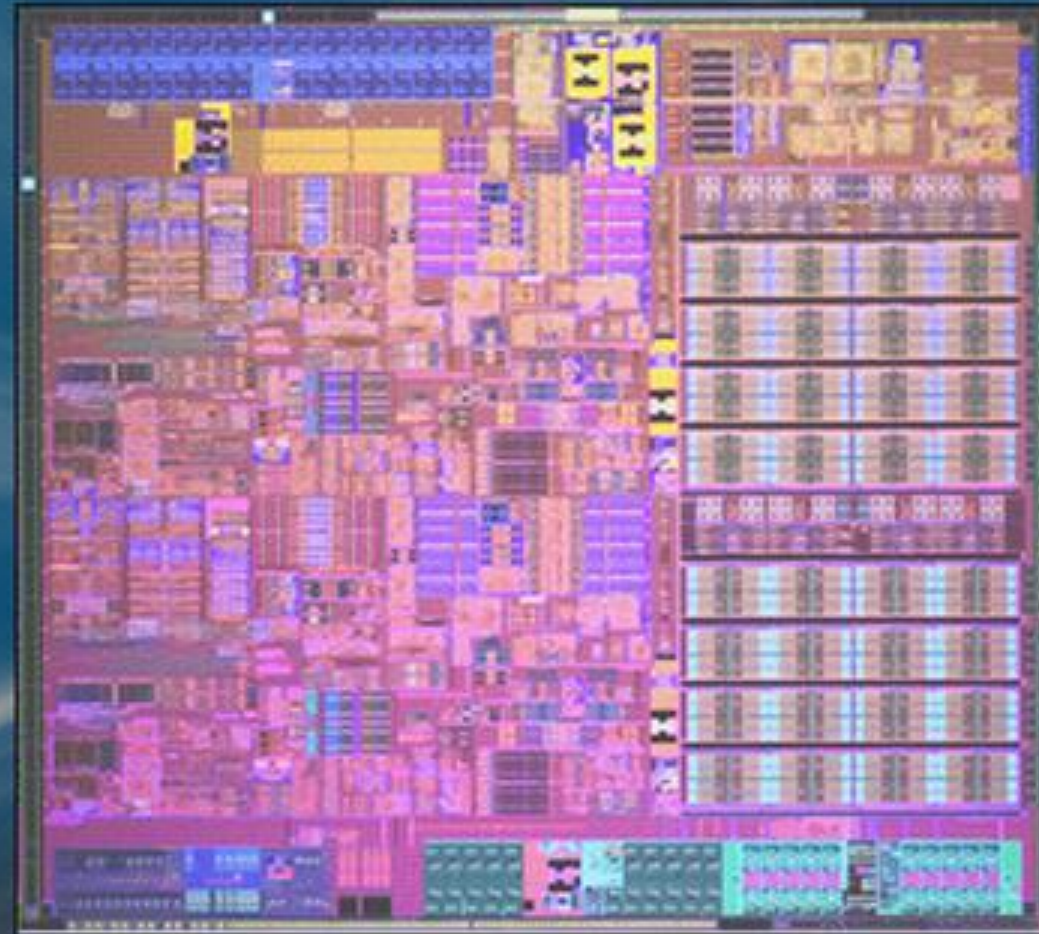
First to demonstrate working 32nm processors

Intel's 32 nm process is certified for production



291 Mbit SRAM 0.171 μm^2 cell size
>1.9 billion transistors 3.8 GHz operation

32 nm Westmere Microprocessor in Production



CPU wafers are moving through the factory
in support of planned Q4 revenue production

32nm Manufacturing Fabs: \$7B Investment Over 2 Years

*D1D
Oregon*



*D1C
Oregon*



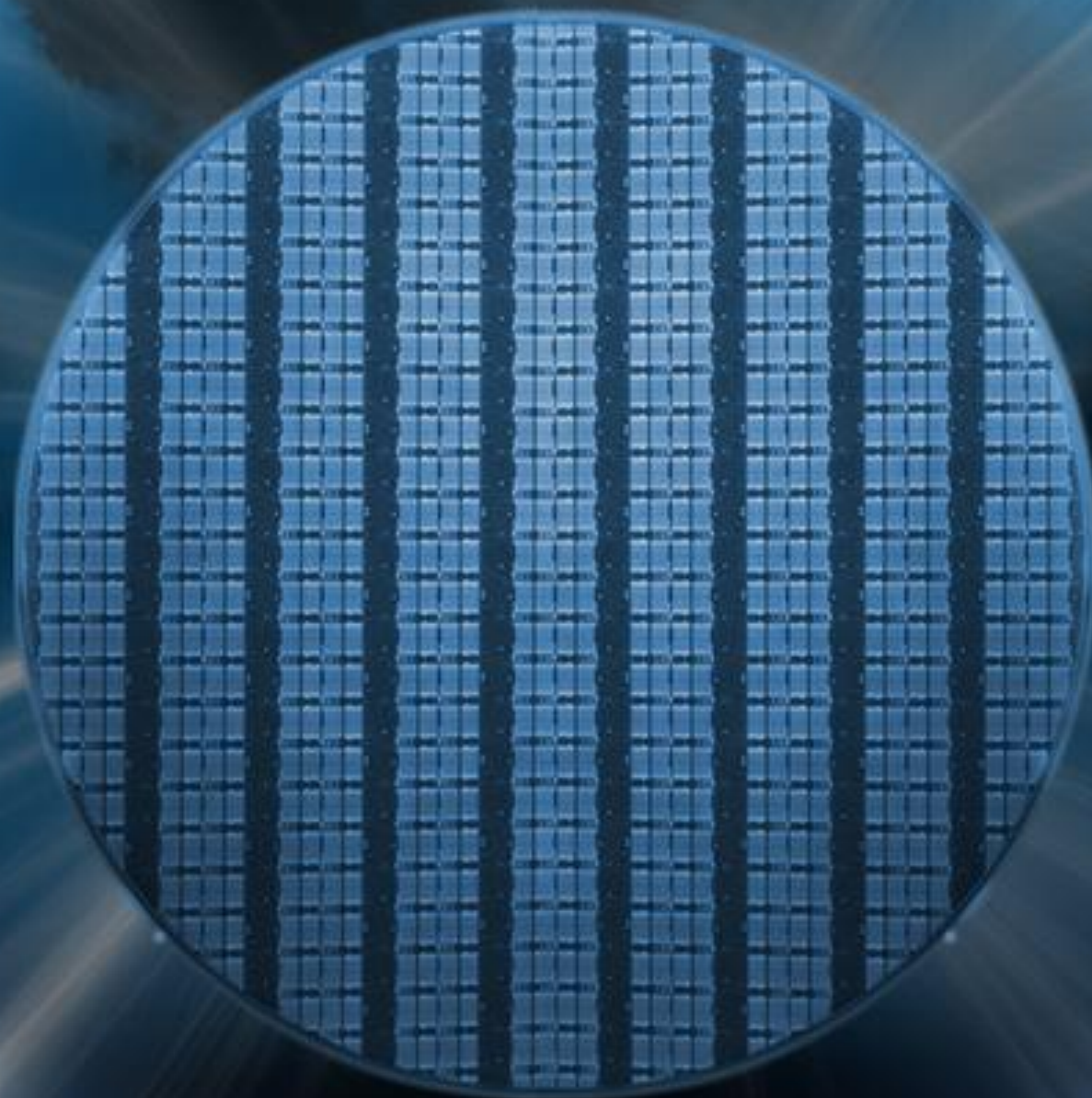
*Fab 32
Arizona*



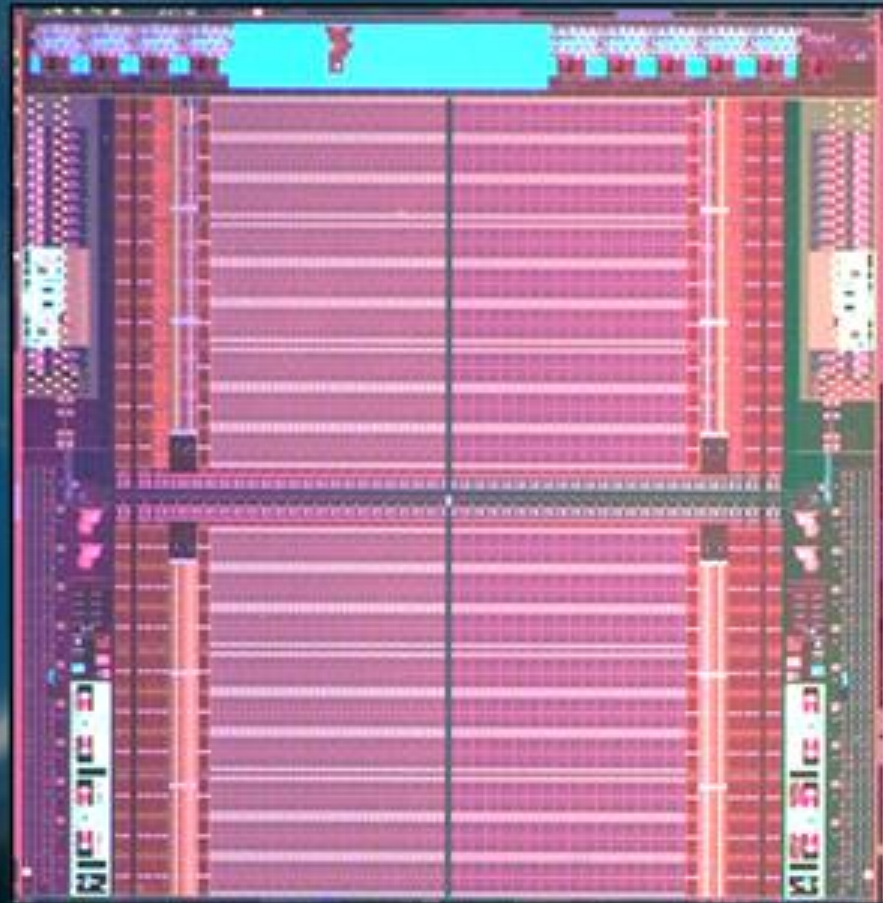
*Fab 11X
New Mexico*



The World's First 22 nm SRAM



The World's First 22 nm SRAM



364 Mbit array size

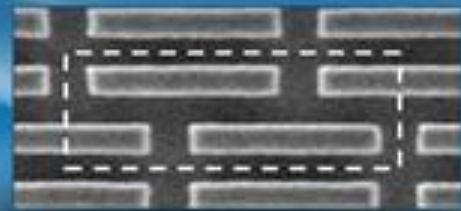
>2.9 billion transistors

3rd generation high-k + metal gate transistors

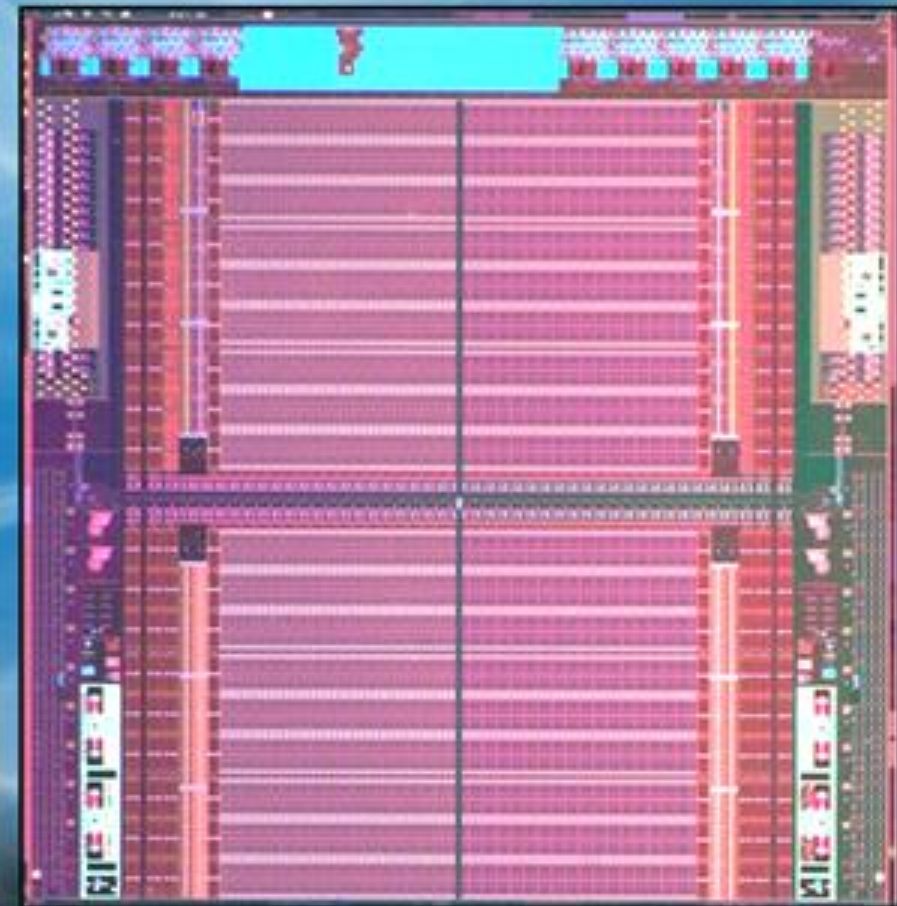
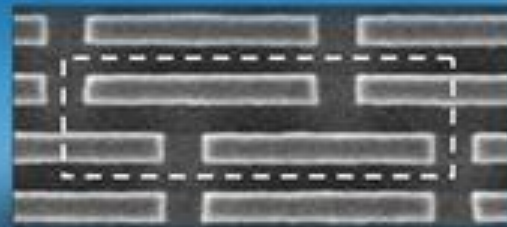
Same transistor and interconnect features as on 22 nm CPUs

22 nm Optimized for Wide Range of Applications

High density
0.092 μm^2 SRAM cell



Low voltage
0.108 μm^2 SRAM cell



0.092 μm^2 is the smallest SRAM cell
in working circuits reported to date



Silicon Leadership: Delivering Innovation

Relentless Pursuit of Moore's Law

Innovations in Silicon Technology

Extending Leadership for New Opportunities

New Segment Opportunities: Internet Connected Devices

CE



Embedded



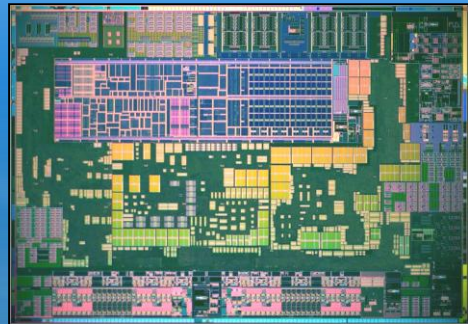
Handhelds



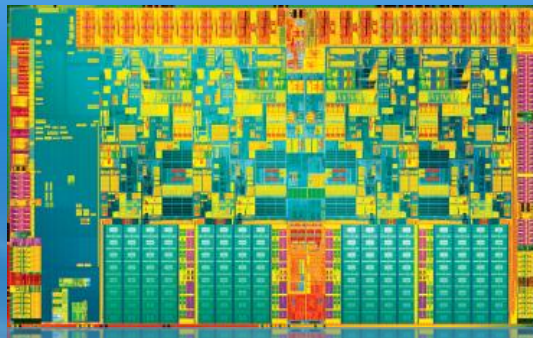
New Segments Require New
Technology and Manufacturing Capabilities

45nm SoCs

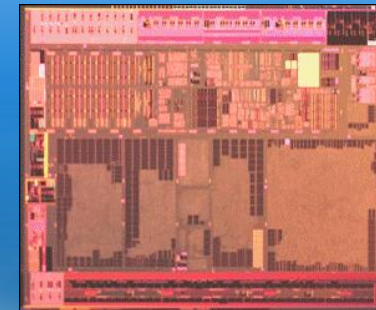
CE
Sodaville



Embedded
Jasper Forest

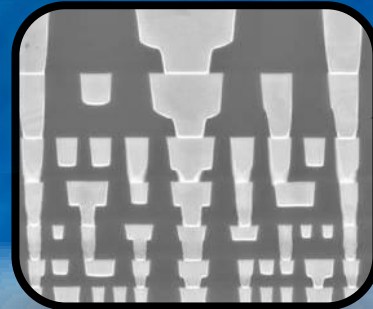


Handhelds
Lincroft

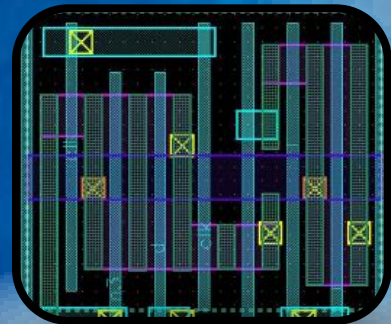
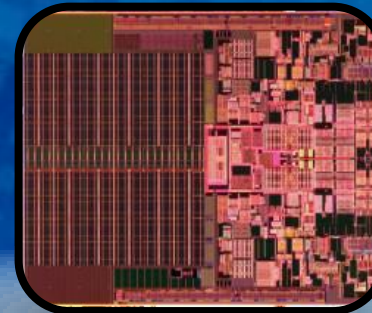


Integrated Device Manufacturer Advantage

Process

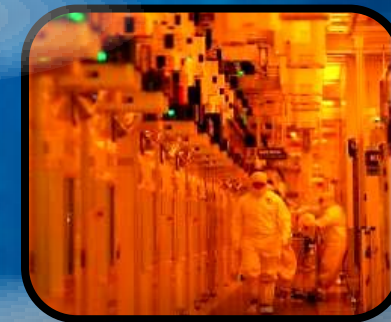


Product



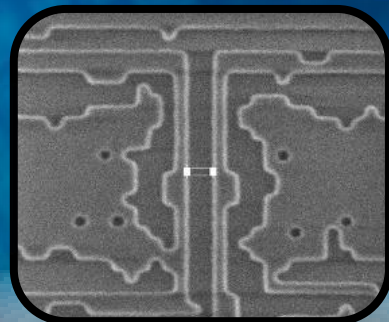
Design
Tools

*Design for Manufacturing
Co-Optimized Process + Product
Rapid Yield Learning
Early Product Ramp*



Manufacturing

Masks



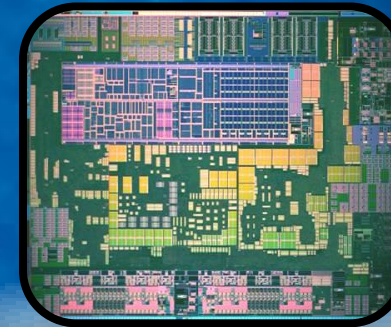
Packaging



Expanded Support for New Opportunities



Customer Support

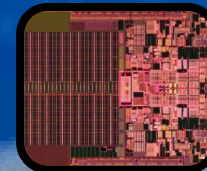


SoCs

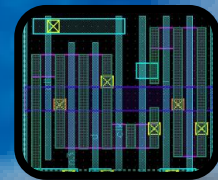
Process



Product



Software



Design Tools

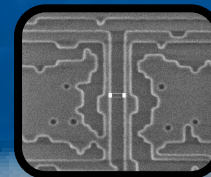


Manufacturing

Memory



Masks



Packaging



Platforms

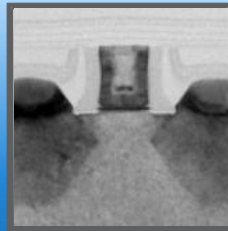


SoC Process Builds on CPU Process

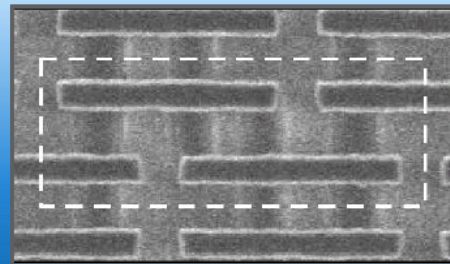
	45nm		32nm		22nm	
	2007	2008	2009	2010	2011	2012
Process:	P1266	P1266.8	P1268	P1269	P1270	P1271
Products:	CPU	SoC	CPU	SoC	CPU	SoC

CPU and SoC versions of each process generation to provide transistors, interconnects and other device features optimized for each product line

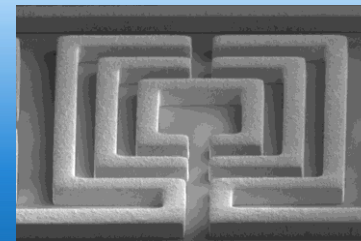
32nm SOC Full-Featured Process Menu



High Perf/Low Power
Logic Transistors



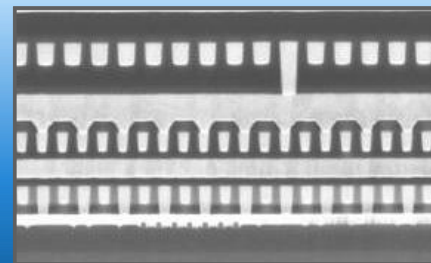
SRAM/RF



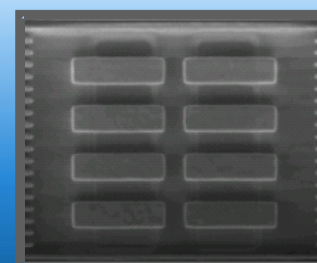
Inductors



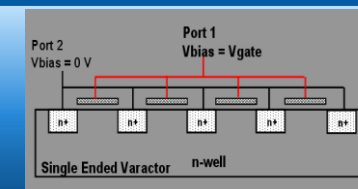
Analog/ HV
I/O Transistors



Precision Linear Capacitors



Decap



Varactors

Variety of Options to Enable Optimized
Silicon Integration of Diverse System Components

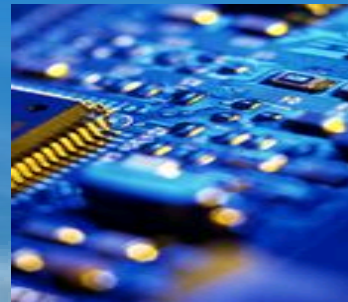
SoC Design and Manufacturing Tools

Benefits: Time to Market, Modularity, Flexibility, Customization

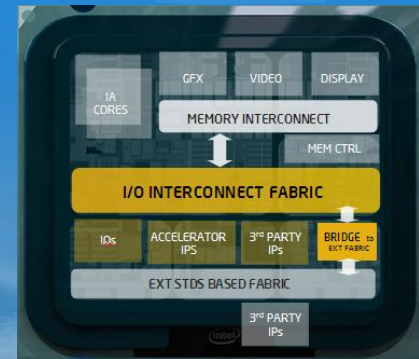
LEADERSHIP
DFx TOOLS



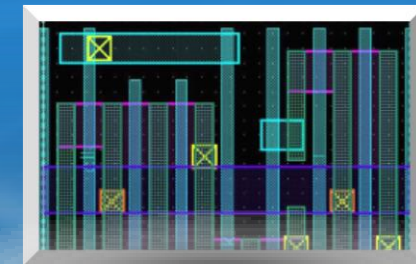
MODULAR SHARED
IP LIBRARY
*Internal or
Customer*



COMMON ARCH
FRAMEWORK



CONVERGED TOOLS
AND
METHODOLOGIES



SoC DESIGN TECHNOLOGY LAYER

Intel 32nm Package Options: Enabling SOC Optimization in Integration, Form Factor and Cost

*MCP FCBGA
2mm thick*



*SINGLE DIE FCBGA
1.6mm thick*



*DISCRETE FCMB
<1 mm thick*



*POP FCMB
<0.8 mm thick*

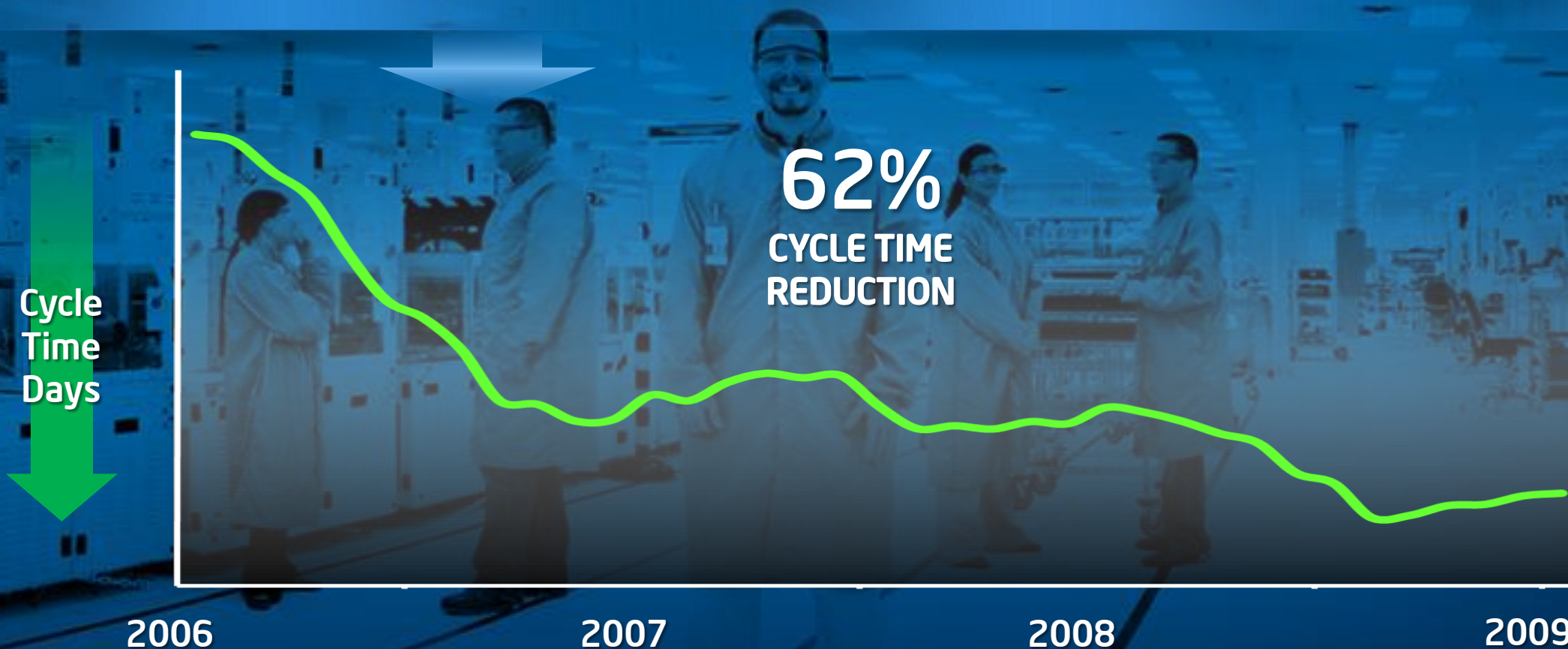


Faster Factories Enable Improved Customer Response

Faster Factories

Better Commitment

Quicker Order to Delivery



Faster Factories Enable Improved Customer Response

Faster Factories

Better Commitment

Quicker Order to Delivery



Faster Factories Enable Improved Customer Response

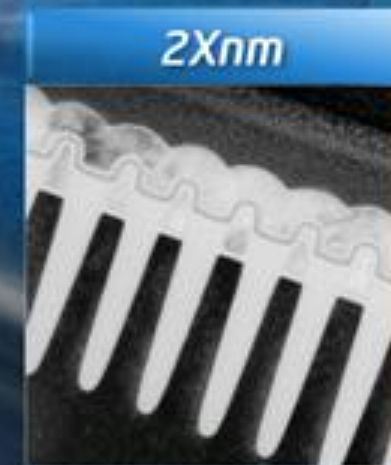
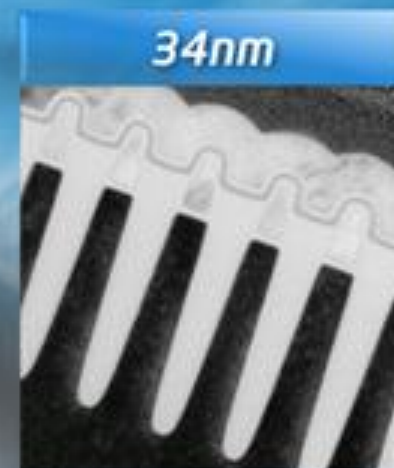
Faster Factories

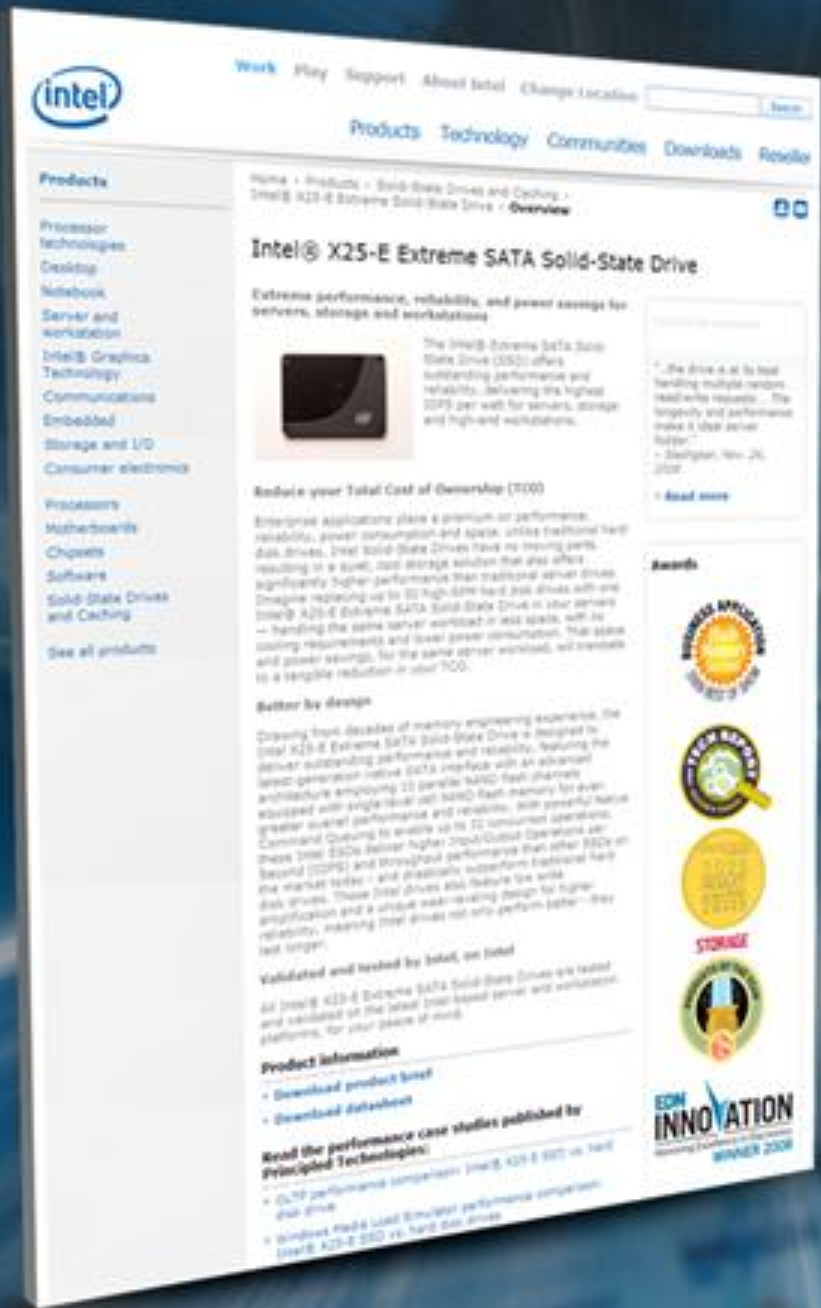
Better Commitment

Quicker Order to Delivery



NAND Scaling: Extending the Possibilities





Rick Coulson
Intel Senior Fellow

Director, Storage Technologies
Technology and Manufacturing Group

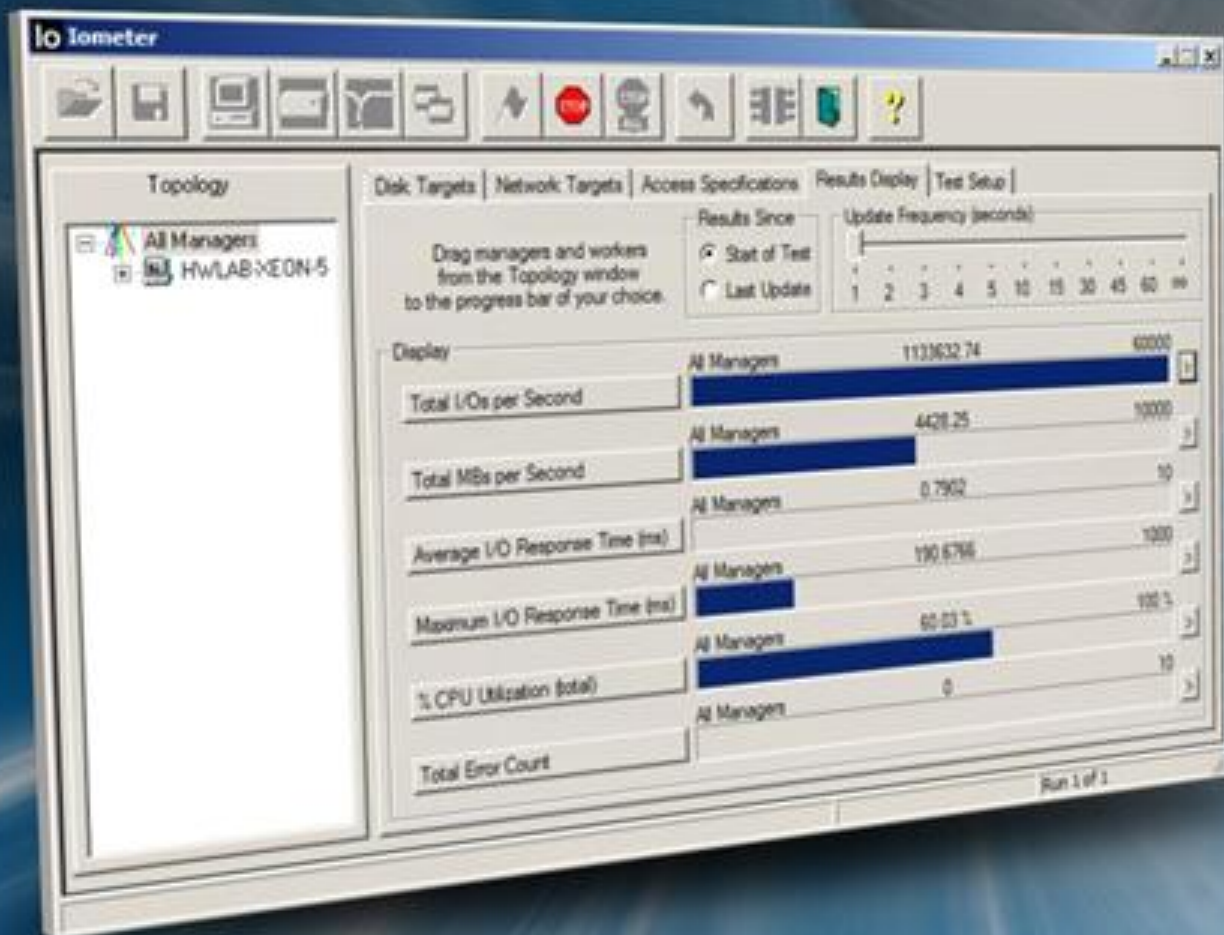
Platform Co-Optimizations with SSDs

SSDs benefit existing platforms

Storage subsystems lag

Co-optimizing SSDs and platform

Improves performance, scalability, power efficiency, total cost



The 'Edit Access Specification' dialog box contains the following settings:

- Name:** 4096 random 512 Read
- Default Assignment:** None
- Table:**

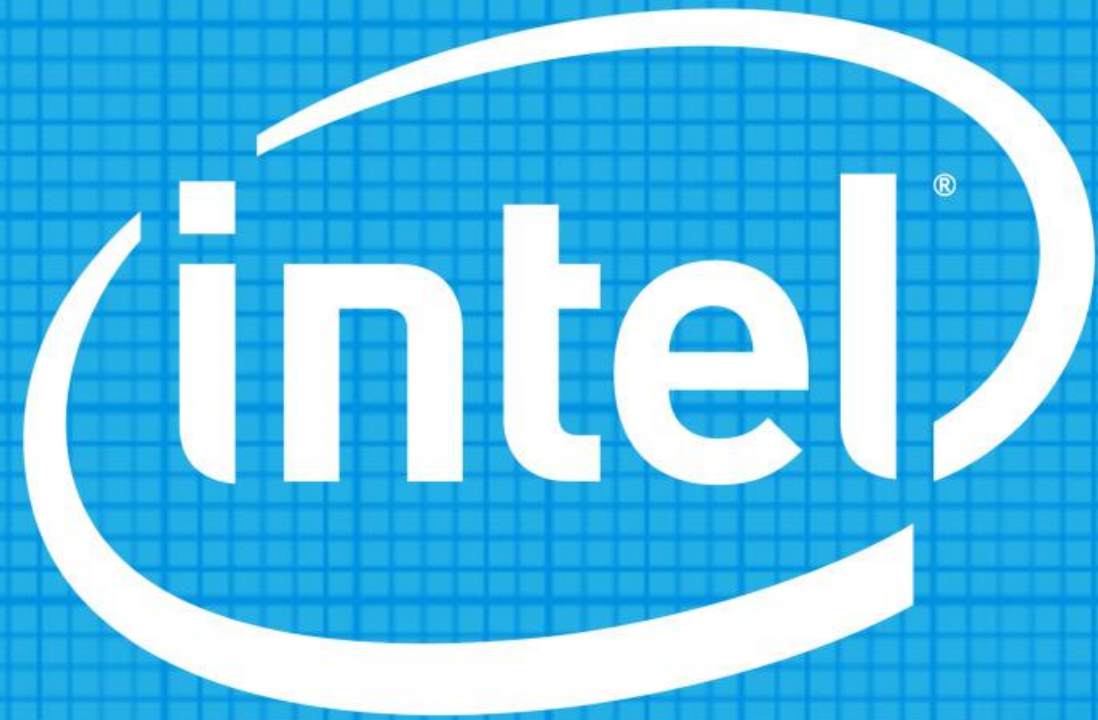
Size	% Access	% Read	% Random	Delay	Burst	Alignment	Reply
0MB - 4KB - 0B	100	67	100	0	1	0MB - 4KB - 0B	none
- Transfer Request Size:** 4 Kilobytes
- Percent of Access Specification:** 100 Percent
- Percent Read/Write Distribution:** 33% Write, 67% Read
- Percent Random/Sequential Distribution:** 0% Sequential, 100% Random
- Burstiness:** Transfer Delay: 0 ms, Burst Length: 1 I/Os
- Align I/Os on:** 4 Kilobytes
- Reply Size:** No Reply

In Closing...

Relentless Pursuit of Moore's Law

Innovations in Silicon Technology

Extending Leadership for New Opportunities



Sponsors of Tomorrow.™