Introduction to
Low-Power VLSI Design

References

Low power CMOS Circuts
Cristian Piguet, CRC press

Low power Methodology Manual for SOC design
Synopsys

Low power digital CMOS design
Anantha P Chandrakasan, Robert W Brodersen, Kluwer Academic Publishers

Practical Low Power Digital VLSI Design
G. K. Yeap, Kluwer Academic Publishers (now Springer), 1998.

Principles of CMOS VLSI Design
Niel E. Weste

Papers

Why low power design?

- Low-power design is a need in VLSI design.
- The increasing prominence of portable systems and the need to limit power consumption (and hence, heat dissipation) in very-high density VLSI chips have led to rapid and innovative developments in low-power design during the recent years.
- The driving forces behind these developments are portable applications requiring low power dissipation and high throughput, such as notebook computers, portable comm. devices, hearing aids, PDAs, pace makers, wrist watches etc.

Consumer Needs vs Energy/Power

- Users want more and more features in their portable devices
  - Camera, High quality sound
  - Video, TV...
- While getting
  - Long battery life
  - Convenient form factor
  - Affordable price
- Battery technology is not evolving fast enough

Power Consumption of VLSI Chips:

Why is it a concern?

1. Battery Size / Weight / Portability
2. Power Dissipation / Density
3. Environmental Concerns

1. Battery Size / Weight / Portability :

- Battery capacity is proportional to its size/weight.

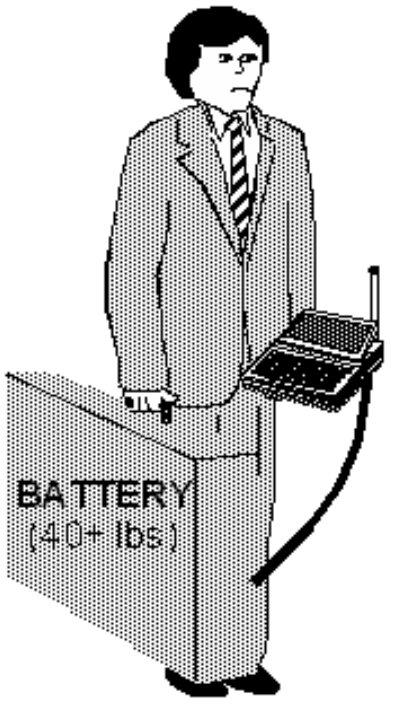
Example:

A high-bandwidth portable wireless communication system, which is not designed for low power may need 40W power

Typical Nickel-Cadmium (NiCd) battery has a capacity of 20W-hr/pound

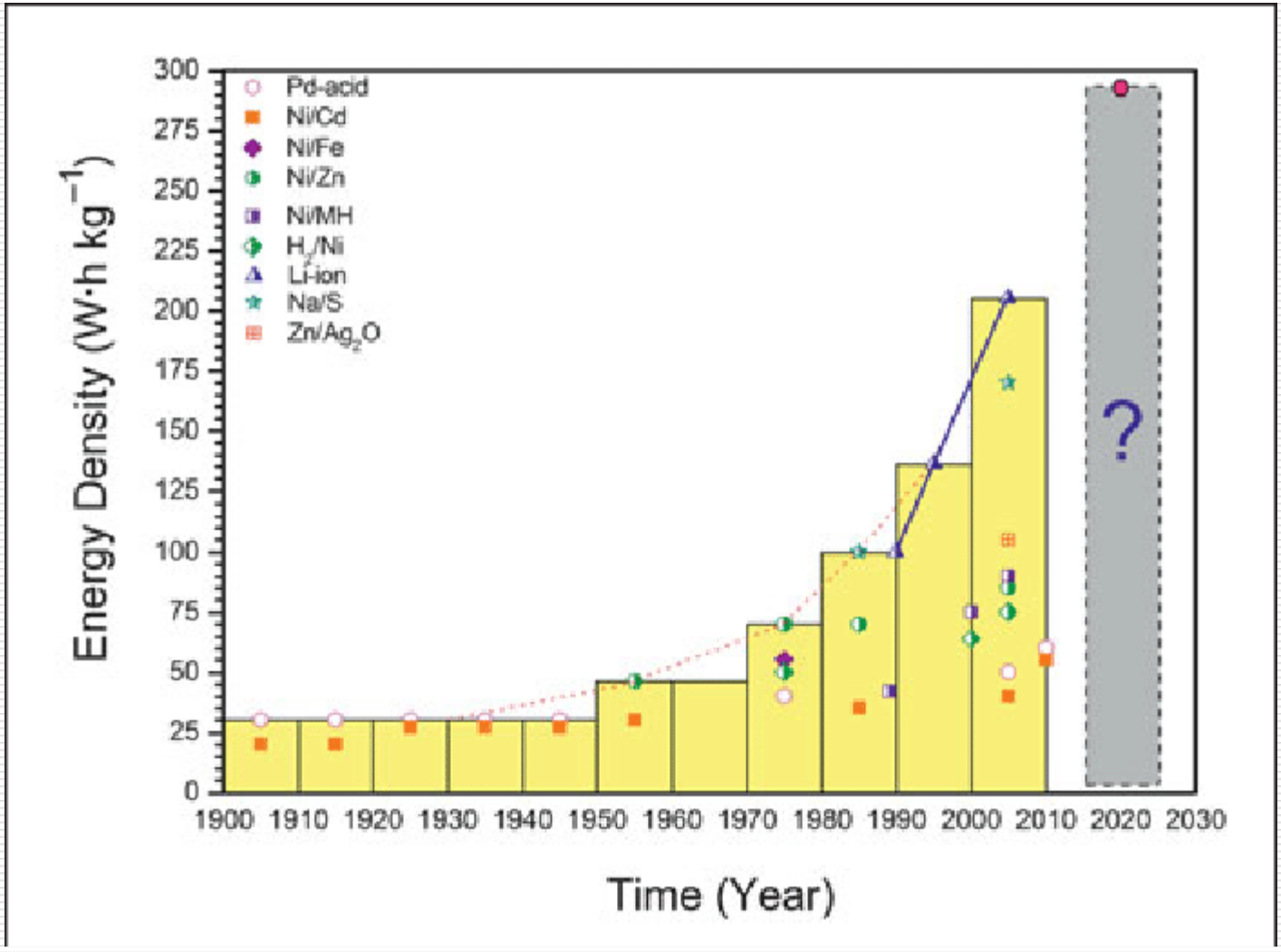
What is the weight of the battery pack required to stretch the recharge interval to 10 Hrs.?

Ans : 20 pounds

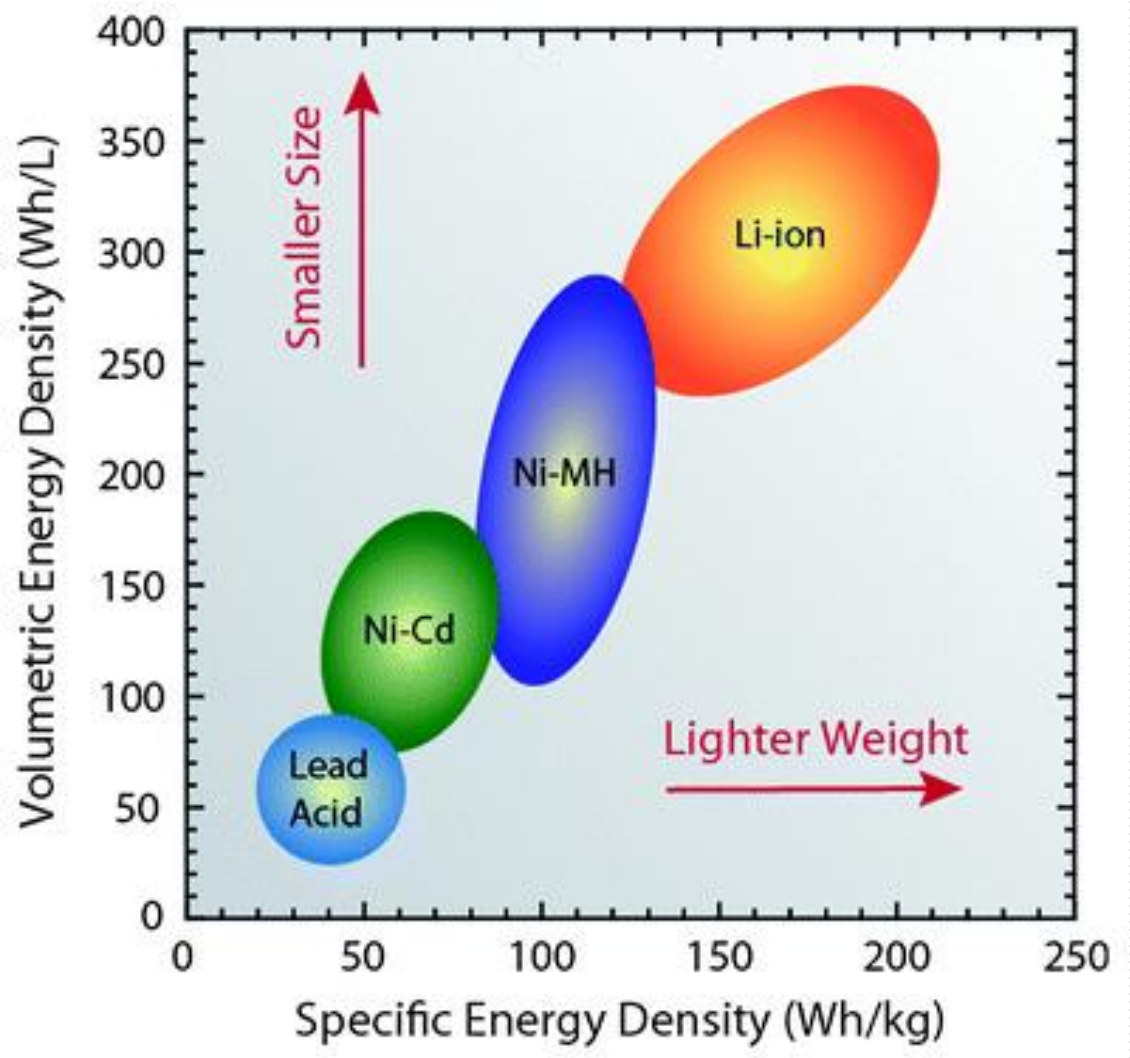


- Hence, in the absence of low-power design techniques, portable products will have either unreasonably heavy battery packs or a very short battery life.

Battery Size / Weight:



Battery Size / Weight:



2. Power Dissipation / Density:

- Significant rise of power dissipation of ICs (microprocessors, DSPs etc.) due to increasing packing density, clock frequency, and computational power
- Power has increased almost linearly with area-frequency product over the years
- Such high power dissipation requires **expensive packaging and cooling techniques**
- Insufficient cooling leads to high operating temperatures, which tends to aggravate several **silicon failure** mechanisms – life time reduces by half for every 10°C rise in temperature

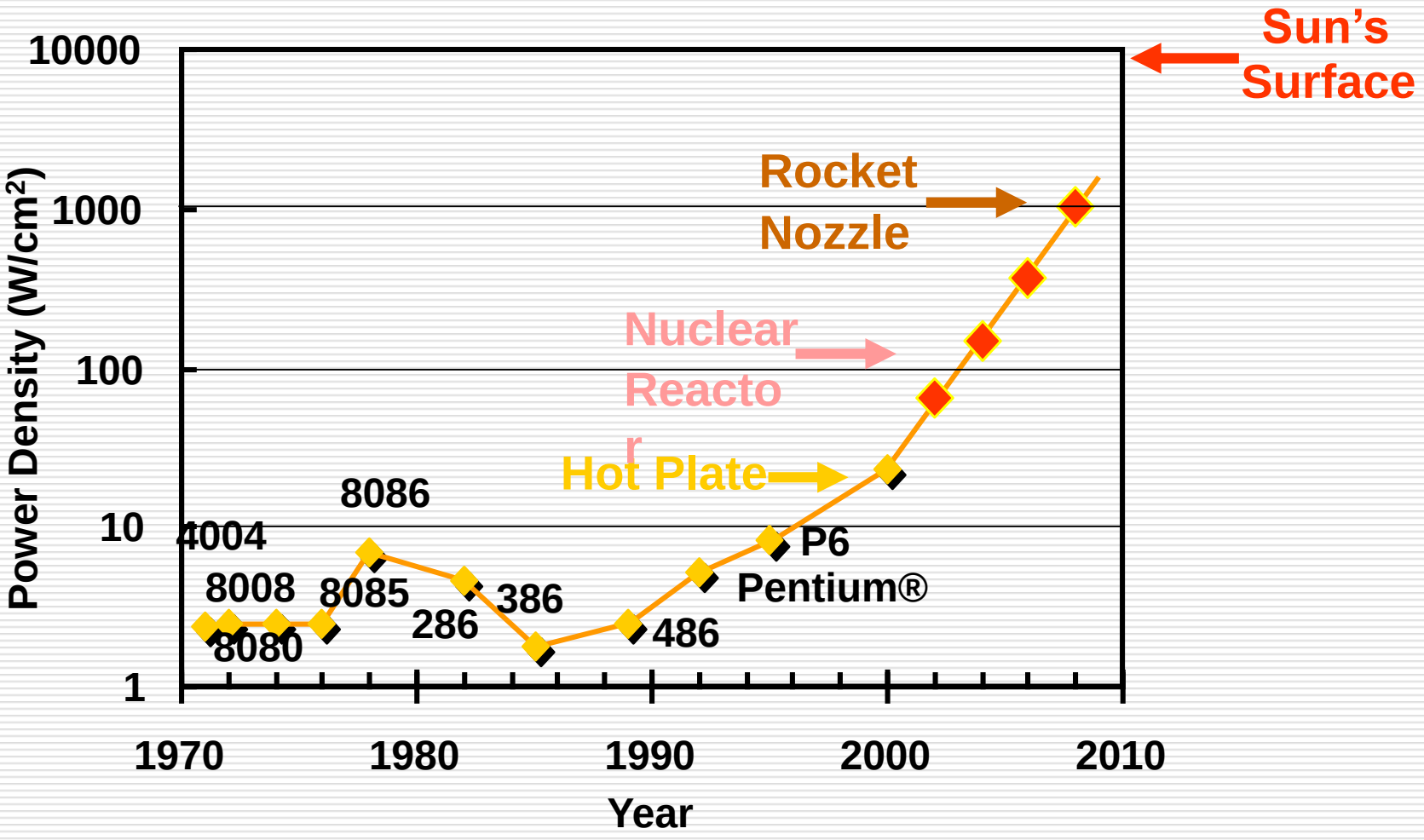
ISSCC, Feb. 2001, Keynote

Patrick P. Gelsinger
Senior Vice President
General Manager
Digital Enterprise Group
INTEL CORP.

"Ten years from now, microprocessors will run at 10GHz to 30GHz and be capable of processing 1 trillion operations per second – about the same number of calculations that the world's fastest supercomputer can perform now.

Unfortunately, if nothing changes these chips will produce as much heat, for their proportional size, as a nuclear reactor. . . ."

VLSI Chip Power Density



Source: Intel®

SIA Roadmap for Processors (1999)

Year	1999	2002	2005	2008	2011	2014
Feature size (nm)	180	130	100	70	50	35
Logic transistors/cm^2	6.2M	18M	39M	84M	180M	390M
Clock (GHz)	1.25	2.1	3.5	6.0	10.0	16.9
Chip size (mm^2)	340	430	520	620	750	900
Power supply (V)	1.8	1.5	1.2	0.9	0.6	0.5
High-perf. Power (W)	90	130	160	170	175	183

Source:
Semiconductor Industry Association

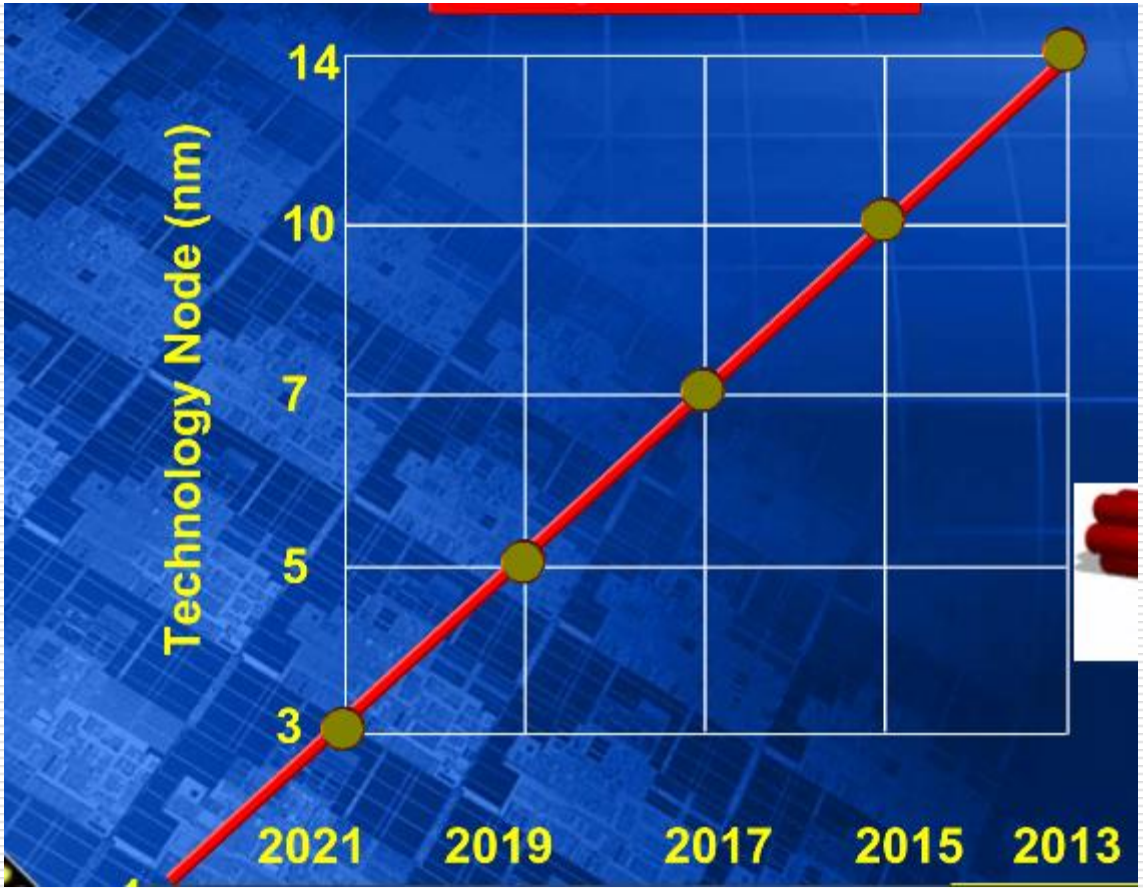
2003 SIA roadmap

Year	nm
2004	90
2007	65
2010	45
2013	32
2016	22

Source: SIA

Source: *http://www.eetimes.com*

2013 SIA roadmap



3. Environmental Concerns:

- Due to increasing percentage of electrical energy usage for computing and communication in the modern workplace, low-power design is in line with the increasing global awareness of environmental concerns

Example:

Studies in 1993 have shown that personal computers in US use $2 billion units of electricity, indirectly produce as much CO_2 as 5 million cars, and account for 5% of commercial electricity consumption (10% by the year 2000)