

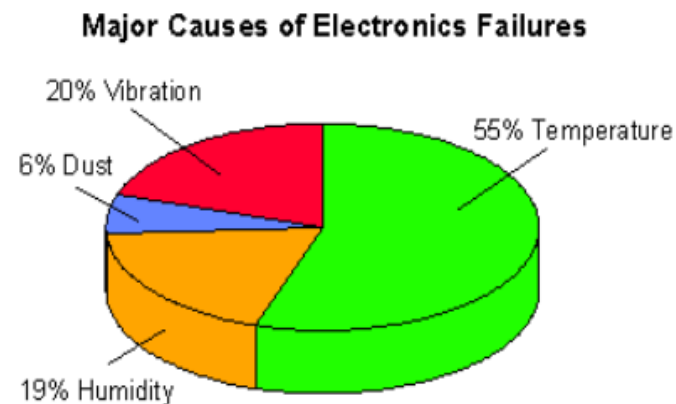
# Microelectronics, BSc course

## Thermal laboratory

Dr. Bognár György, Hantos Gusztáv, Dr. Szabó Péter

# Thermal problems? Why should we care?

- Higher performance requires devices with higher dissipation which calls for cooling equipments with higher efficiency
- What happens if the temperature increased?

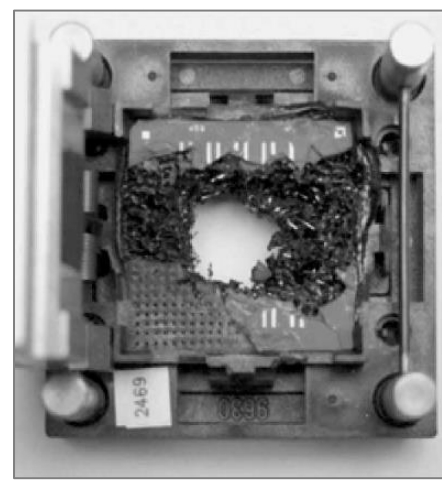
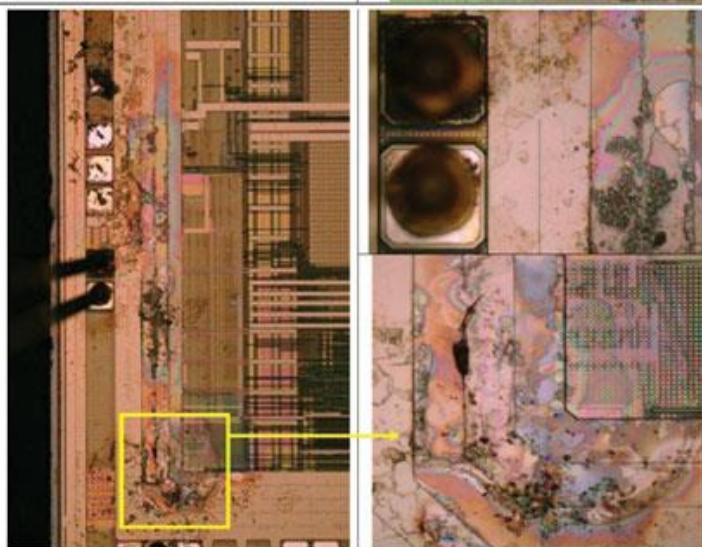
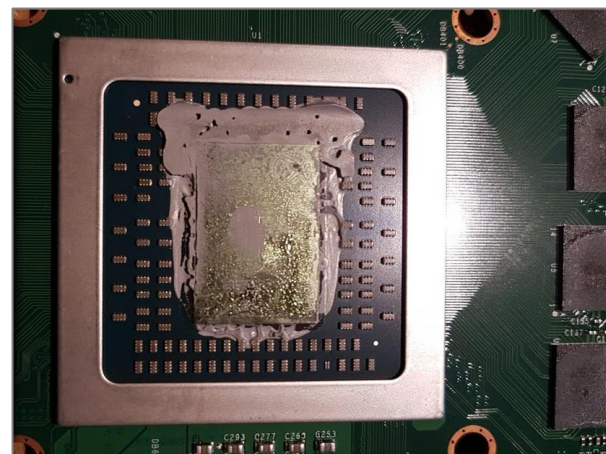
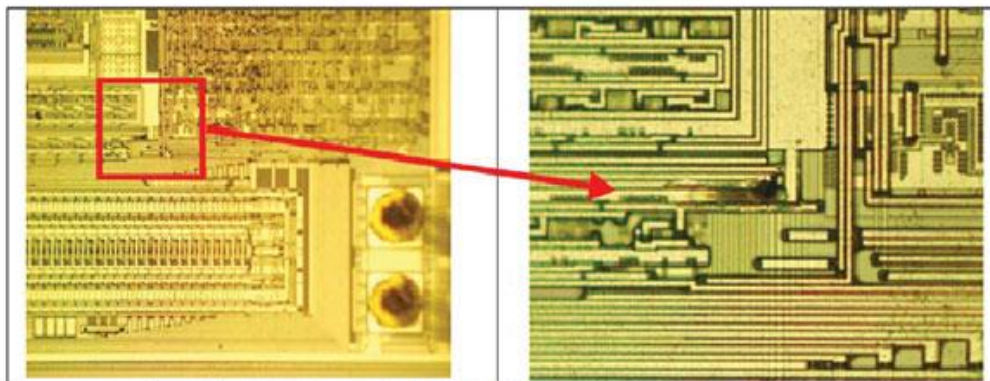


(Source : US Air Force Avionics Integrity Program)



# Thermal problems? Why should we care?

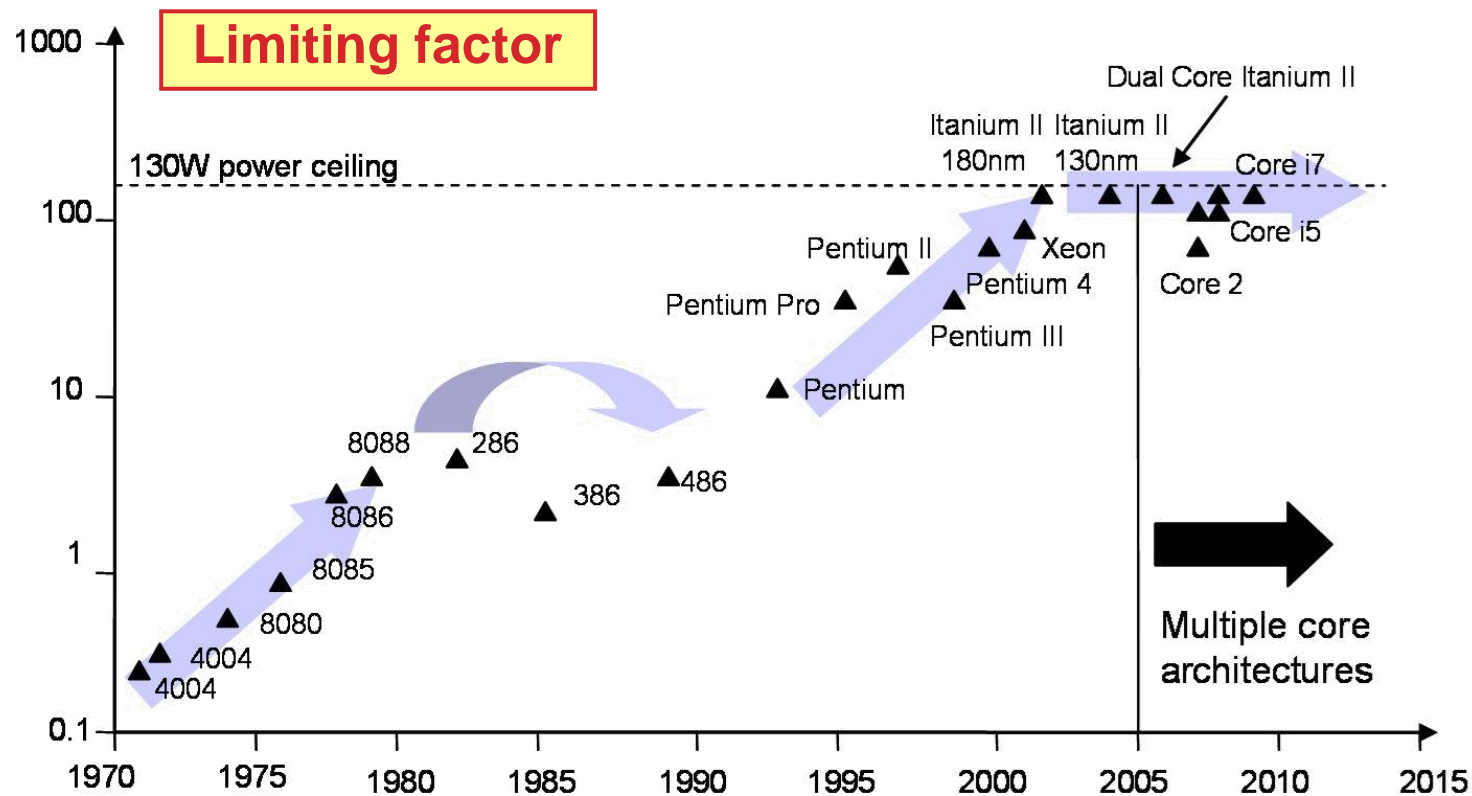
- Increased dissipation, thermal runaway





# Power consumption trend

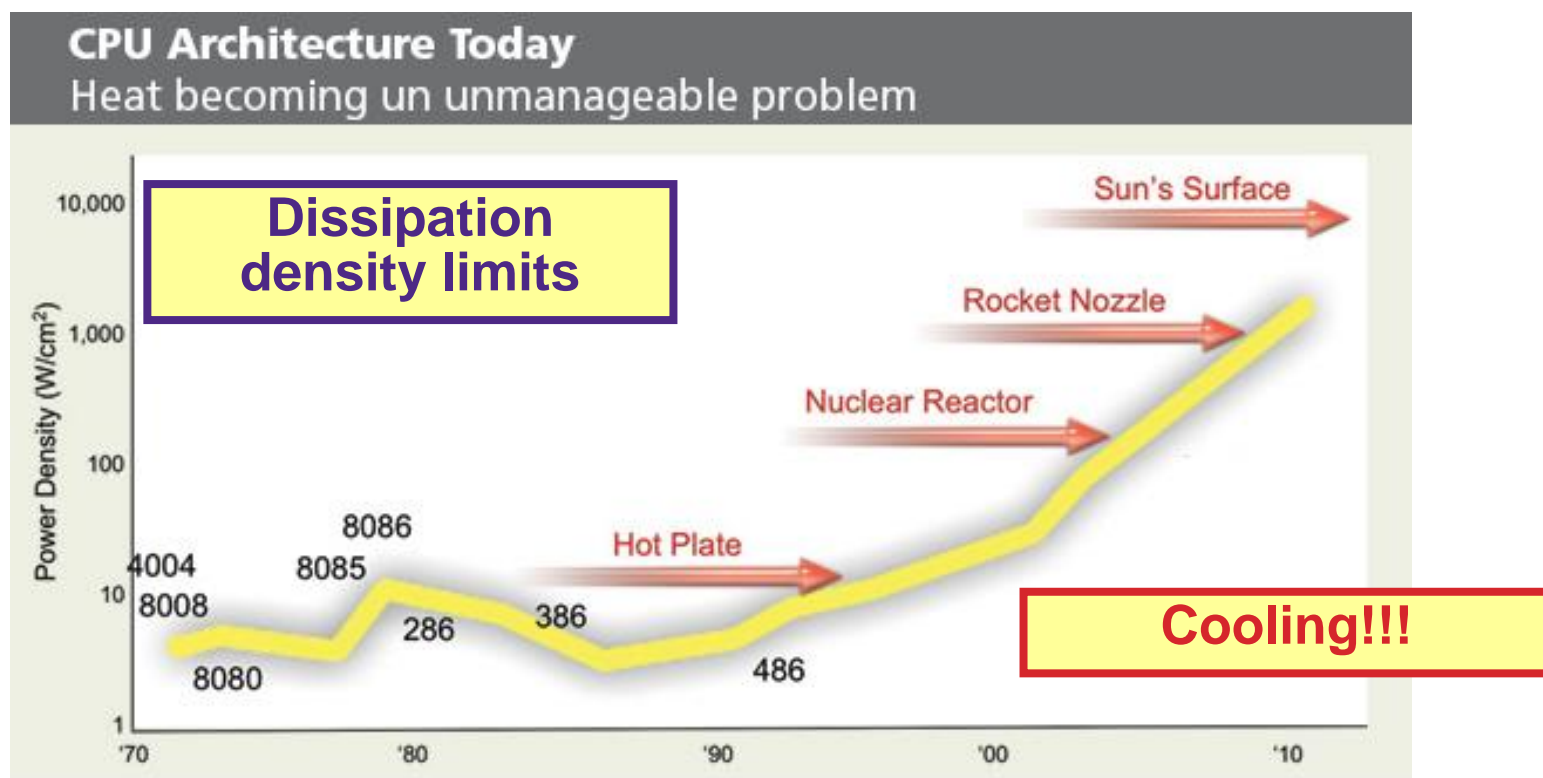
- Continuous increase in case of processors



Adapted from ARC 2010 presentation by Dr. Ram Krishnamurthy, Intel Research

# Increase in dissipation density

- Power consumption growth faster than the die size

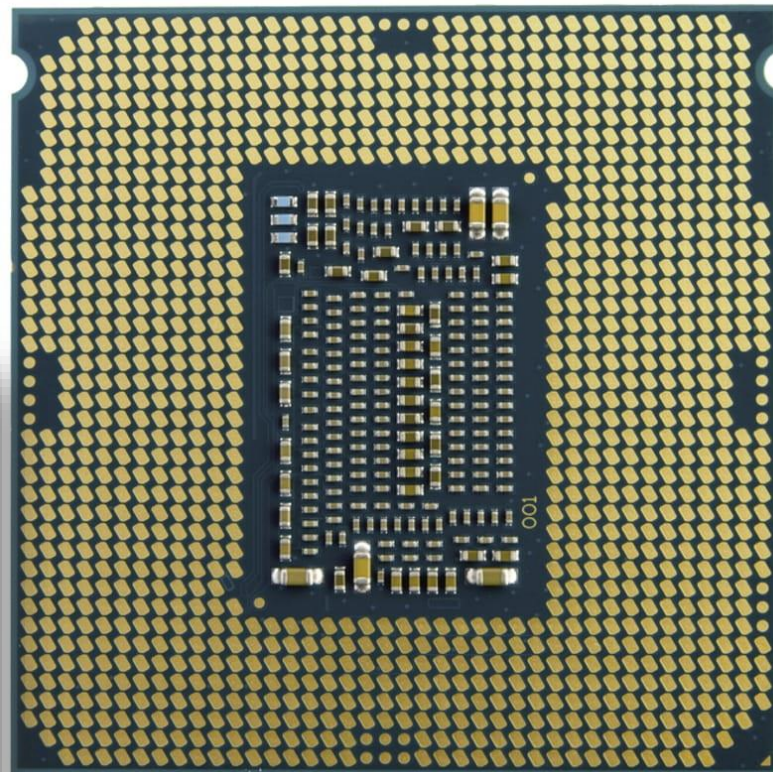


In CPU architecture today, heat is becoming an unmanageable problem.  
(Courtesy of Pat Gelsinger, Intel Developer Forum, Spring 2004)

# State-of-the-art packaging technologies

## FCLGA package

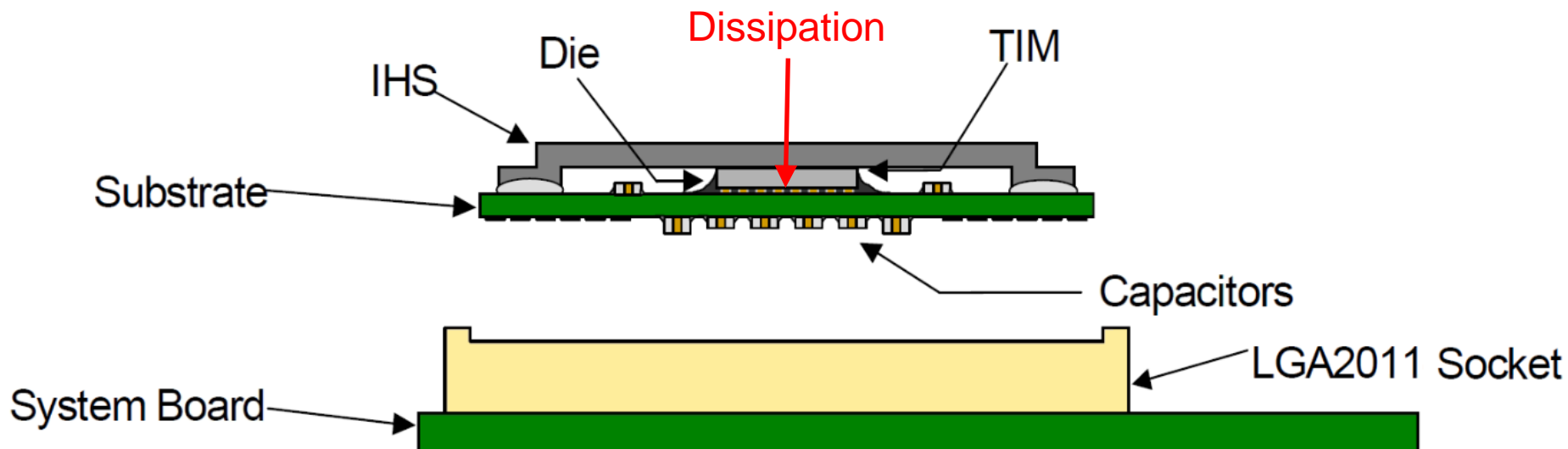
- Large number of pins
- $\sim 100$  W power,  $V_{\text{core}} \sim 1$  V
- $\sim 45\ldots 55$  % of the pins are GND or VDD



# Heat flow in state-of-the-art packagings

## FCLGA packaging

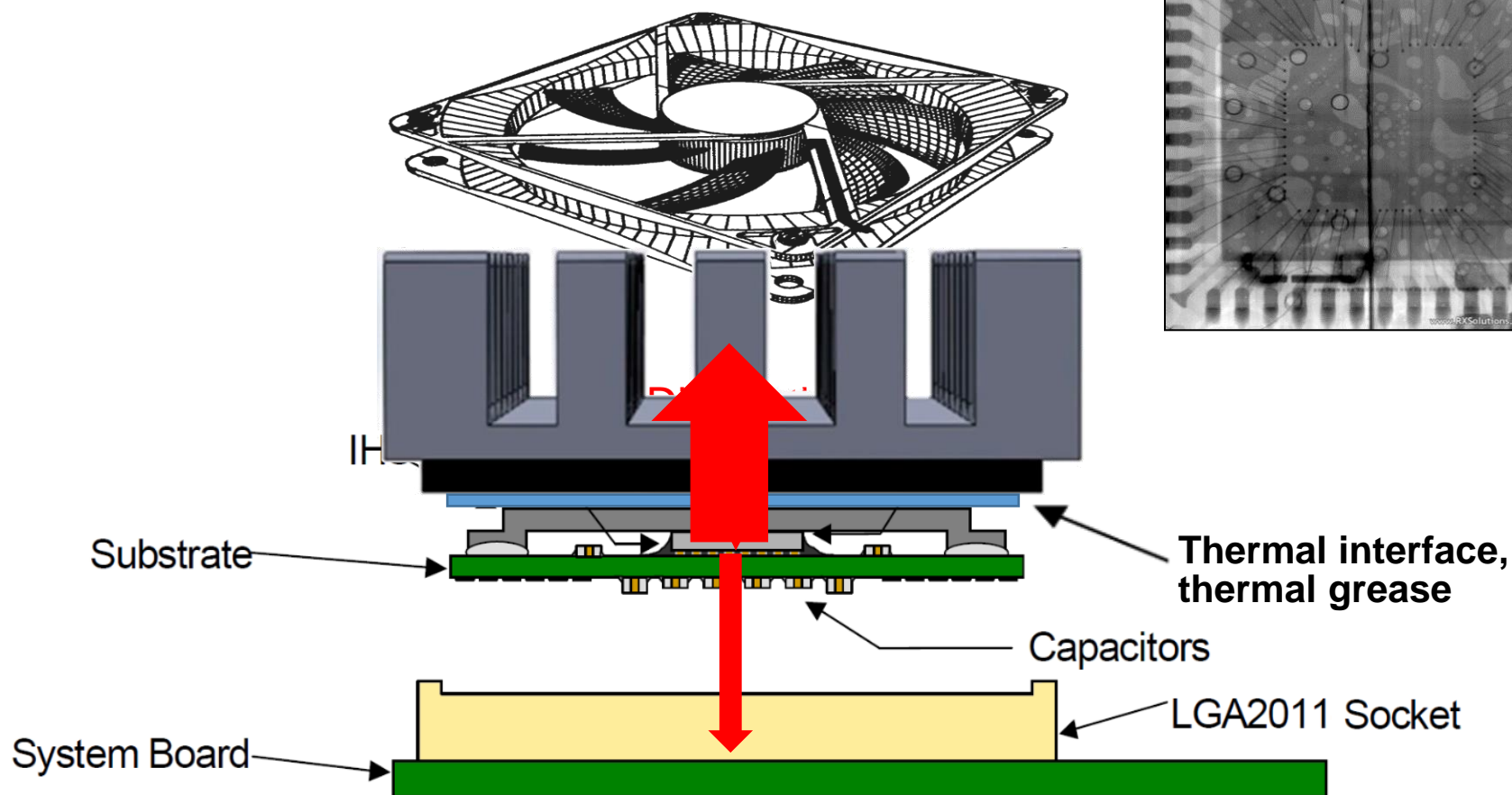
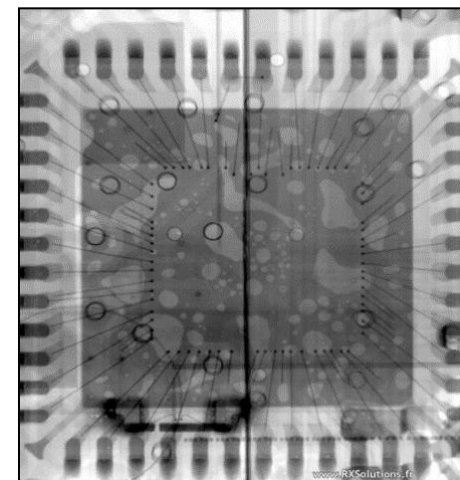
- Chip placed on organic/ceramics/silicon interposer,
- Flip-chip technique,
- 2D heat flow path,
- 1000...2000 pins



# Heat flow in state-of-the-art packagings

## FCLGA packaging

- Importance of the thermal interface material (TIM)

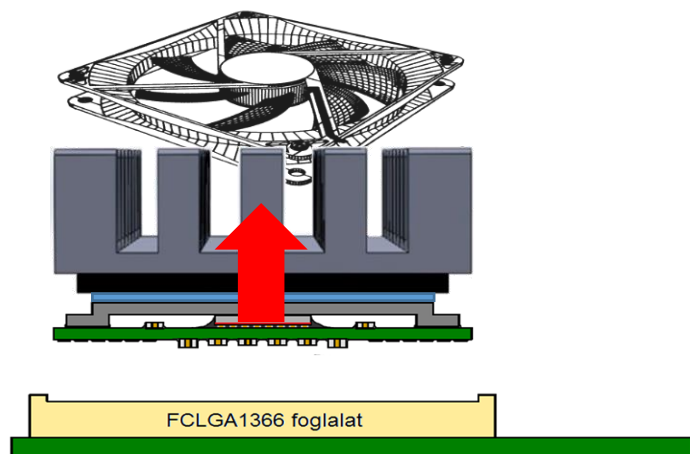
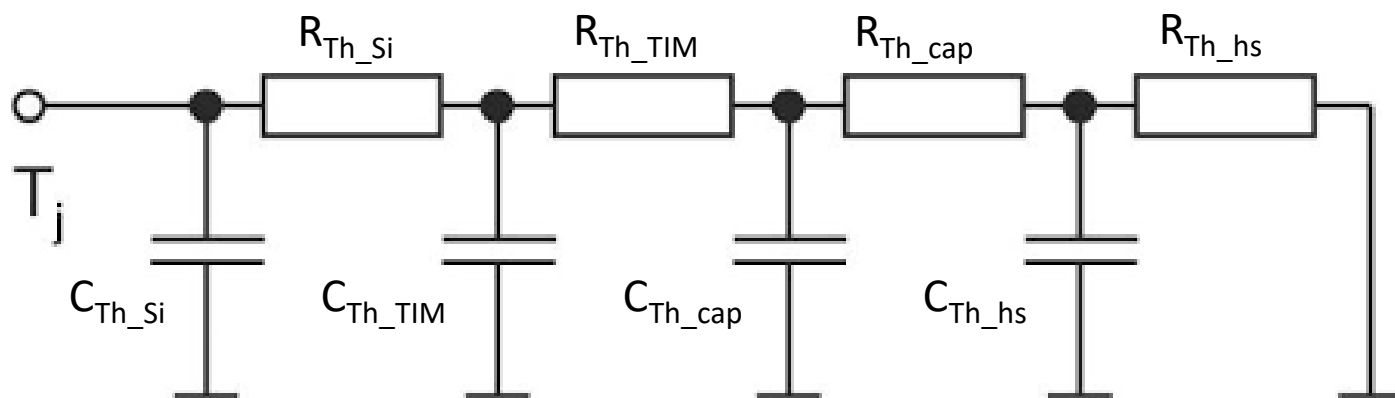




# Heat flow in state-of-the-art packagings

## FCLGA packaging

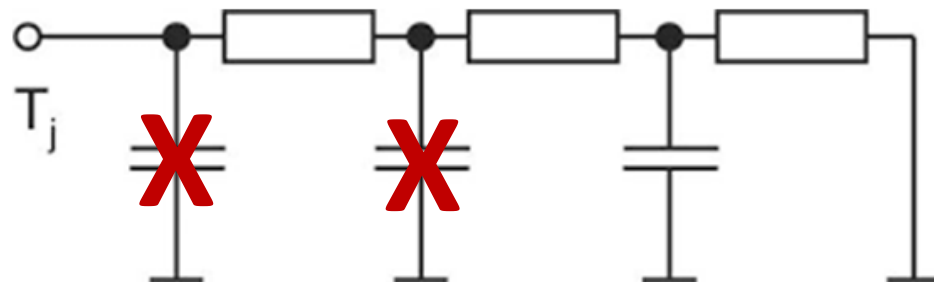
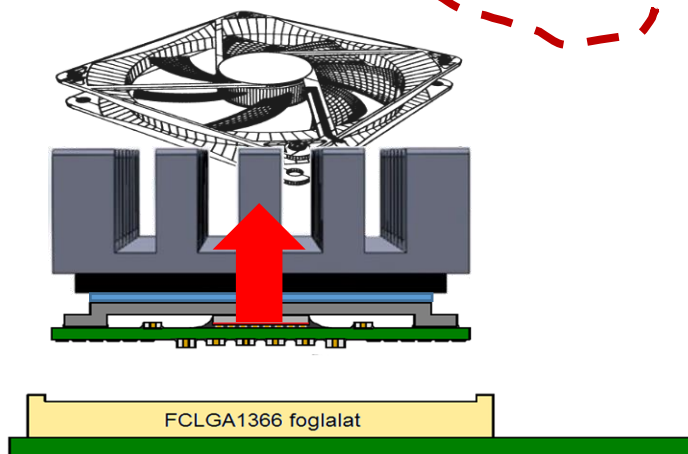
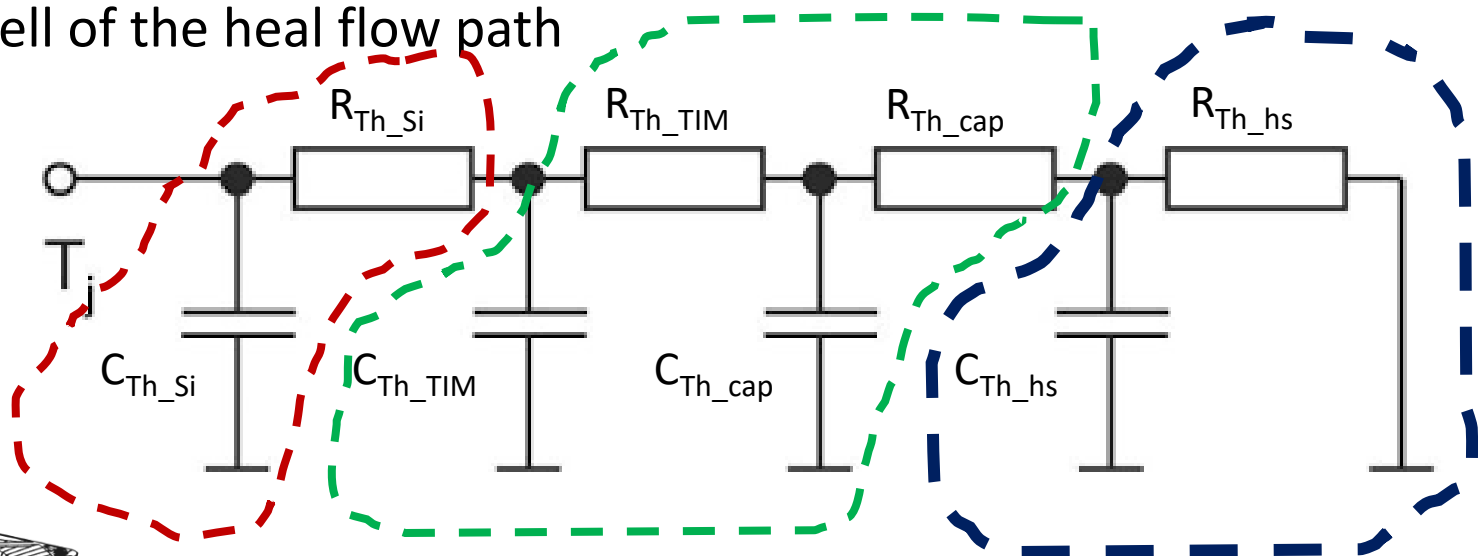
- 1D RC modell of the heal flow path



# Heat flow in state-of-the-art packagings

## FCLGA packaging

- 1D RC modell of the heal flow path



# Heat flow in state-of-the-art packagings

- 3D structures (System-on-Package), More-than-Moore integration worsen the situation

## DRAM és processzor közöstokozása mobil eszközökben



*Tokozott Apple A4 rendszerchip*

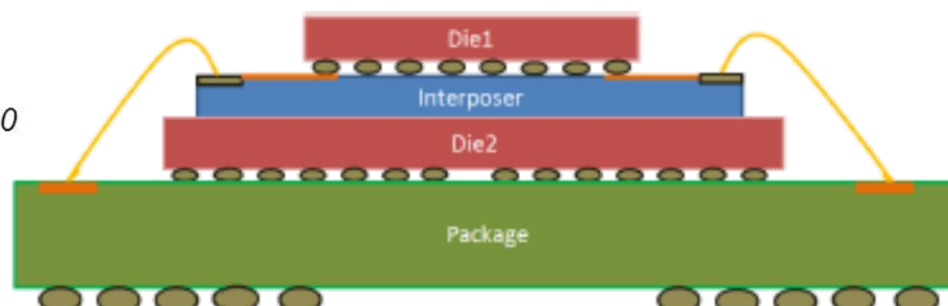
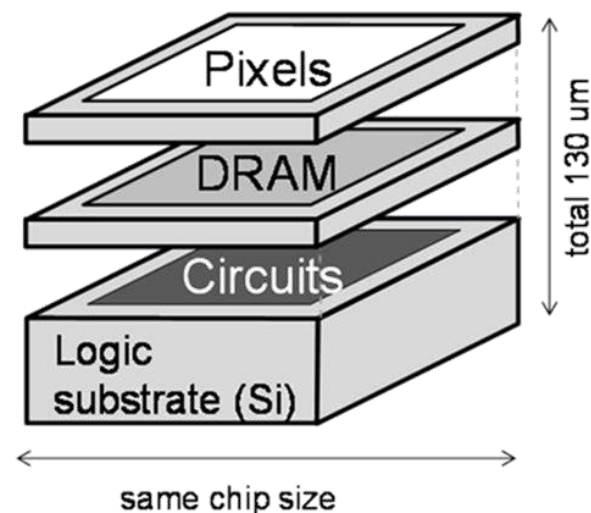


← Két egymásra  
helyezett DRAM chip

← Processzor chip

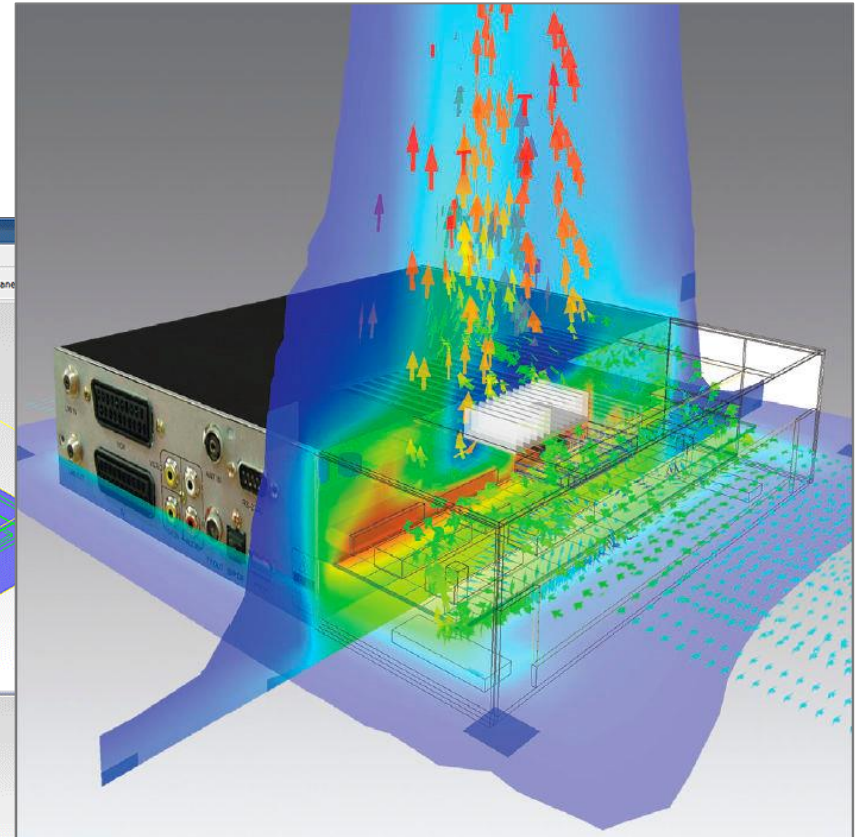
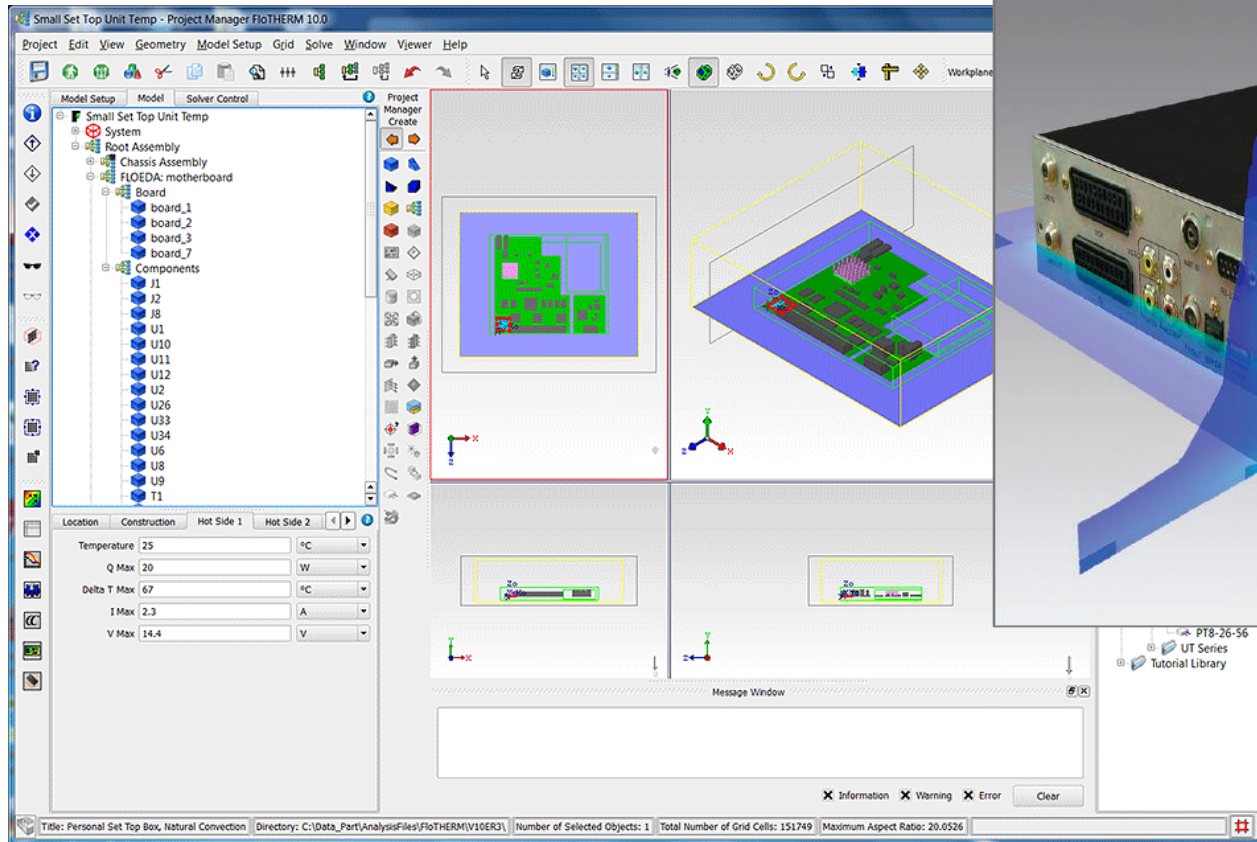
*Tokozott Apple A4 rendszerchip keresztmetszeti ábra, iFixit 2010*

## Structure of modern image sensors



# Thermal simulators

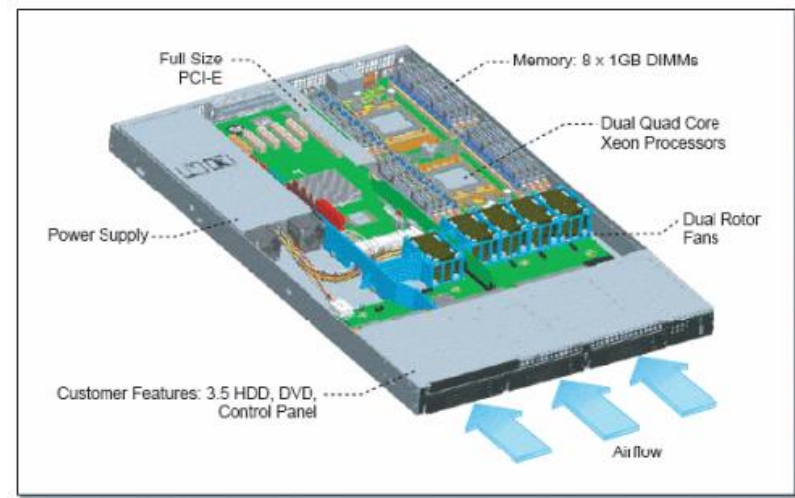
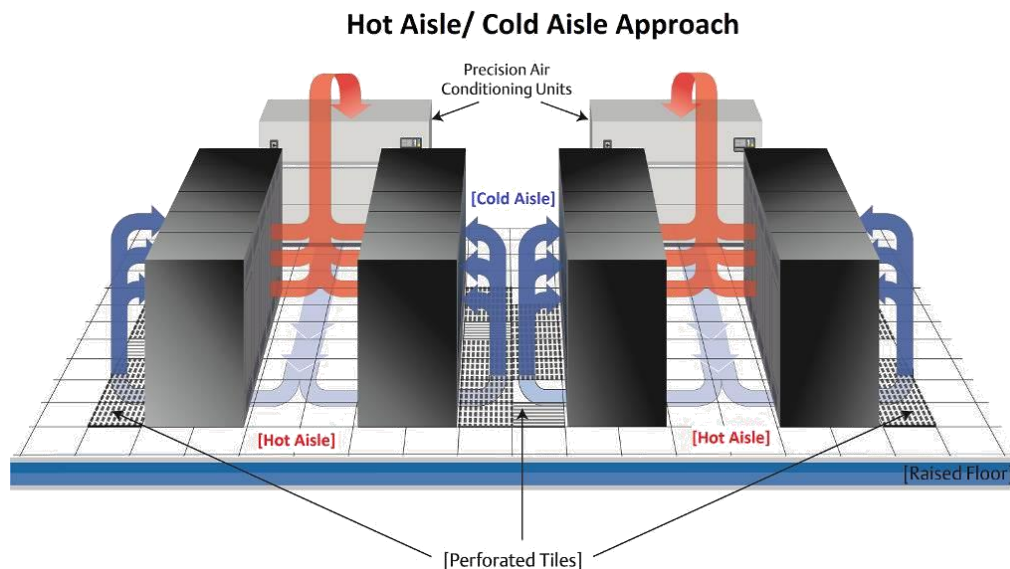
- Siemens Mentor - Flotherm CFD





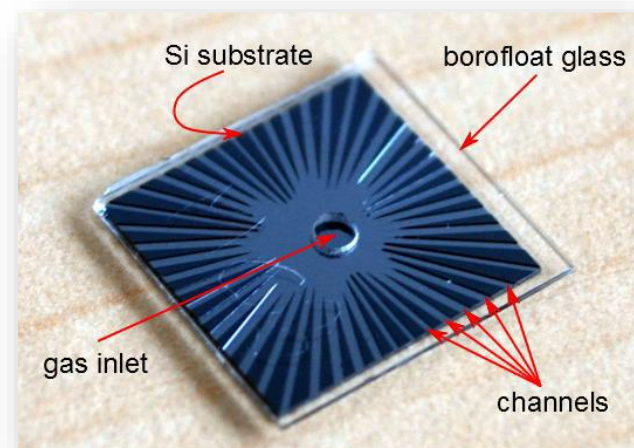
# Data center cooling

- Data centers require unique room conditioning setup and power recycle
  - Increased dissipation in racks with little room for fans
  - Power usage can be compared to the national power supply



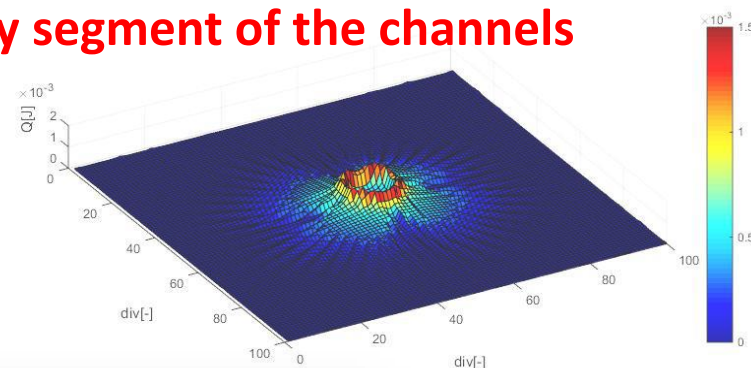
# Microchannels for integrated cooling

- 2014-2018 - OTKA K 109202 – **Integrated thermal management for System-on-Package devices**

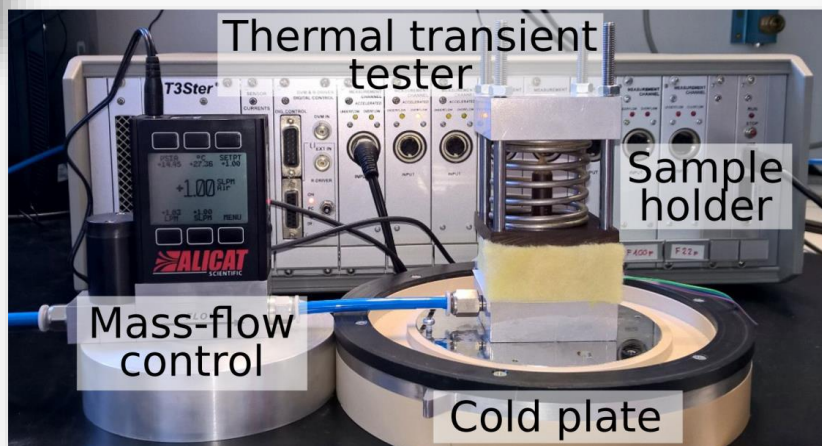


**Manufacturing technology to integrate the cooling into the silicon itself**

**Identifying the value of heat transfer in every segment of the channels**



**CTM development**



**Measurement setup**