CPU Cooling

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Introduction

- Power Consumption Generates Heat – Joule Heating
  - Dynamic Power
  - Short Circuit Current
  - Leakage
- Transistor Density
  - Intel Core i7-4770k – 1.4 billion finFETs / 160mm^2
- Power Density Ceiling

Effects of Heat

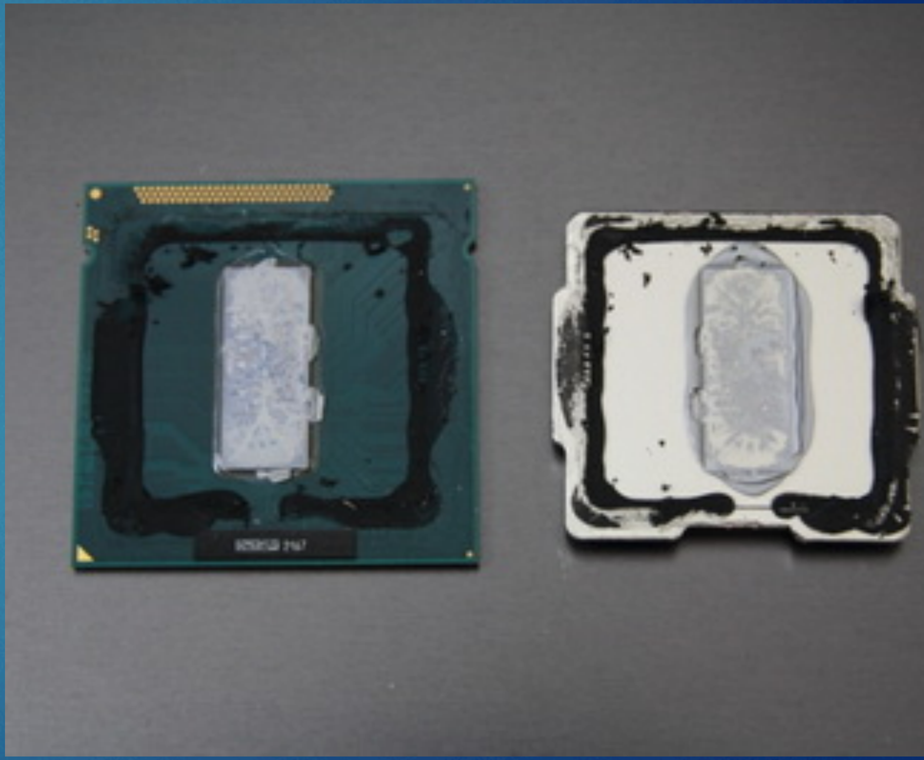
- At semiconductor level, heat changes junction behavior
  - Increased heat → increased resistance
  - Past 160 °C → decreased resistance
  - Thermal runaway → device failure
- High operating temperature decreases processor life
  - 10 °C increase → lifetime decrease ~50% (Arrhenius equation)

CPU Power Consumption

- Chips have TDP (Thermal Design Power) ratings
  - The maximum amount of heat dissipated
  - Intel i7-4770K: 84W TDP
  - Intel i3-4200Y: 11.5W TDP
- Clock frequency - Overclocking

CPU Packaging

- Chip → thermal paste → heat spreader
- Paste creates full contact between surface of the chip and heat spreader
- Thermal paste: Ceramic or metallic based
- Heat Spreader: Copper



Potential Cooling Solutions

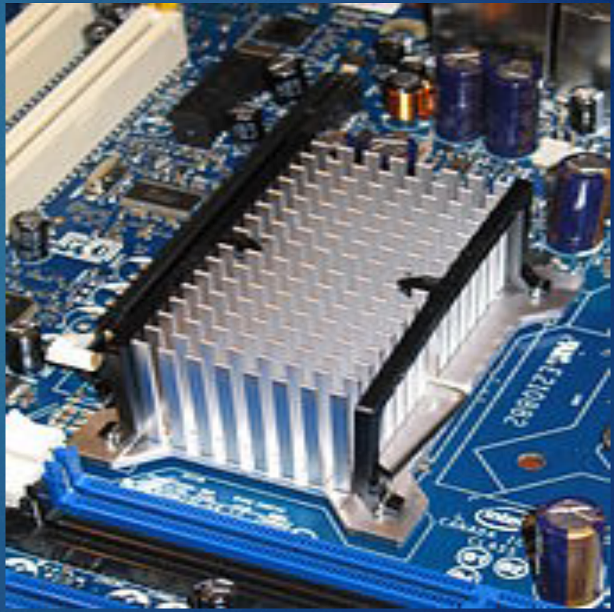
- Microjet technology
  - Capable of cooling 1,000W / cm^2
  - Circulates hydro-fluorocarbon (dielectric) through channels on top of the chip
  - Phase change cooling
- Magnetic cooling
  - Magnetizes/demagnetizes to transfer heat

Passive Cooling

- No input power required
- Thermal conduction, natural convection and radiation
- Easy to design
- Inexpensive
- Worse performance than active cooling

Passive Cooling

- Heat sink
  - Large thermal capacity, large surface area
  - Al or Cu for good conductivity
  - Fins to increase surface area
  - Problem with dust



Active Cooling

- External input power required
- Adaptive vs. Non-adaptive
  - Closed-loop feedback of the chip’s temperature
  - Dynamic cooling
- More effective
- More design complexity and expensive

Active Cooling

- Fan-based air cooling
  - Combination of fans
    - Parallel: double the free air flow, pressure unchanged
    - Series: double the pressure, but free air flow unchanged
  - Usually coupled with heat sinks
    - Most widespread technique

Liquid Cooling technology

Five Components:

1. Integrated pump
2. Integrated pump and cold plate unit
3. Heat exchanger
4. Liquid tubes
5. Cooling liquid

Source:http://hothardware.com/Reviews/Asetek-Low-Cost-Liquid-Cooling-LCLC-System/?page=2

Liquid Cooling technology

1.CPU generates heat

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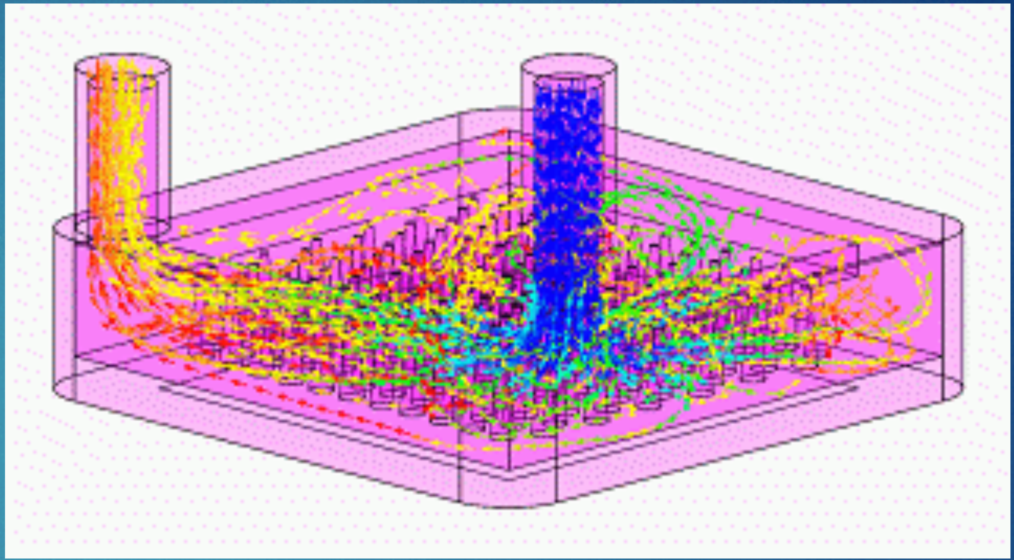
Liquid Cooling technology



Source: http://en.wikipedia.org/wiki/File:CFD_Liquid_Cooled_Cold_Plate_v4.gif

2. Heat transfers through cold plates into cooling liquid

1.CPU generates heat

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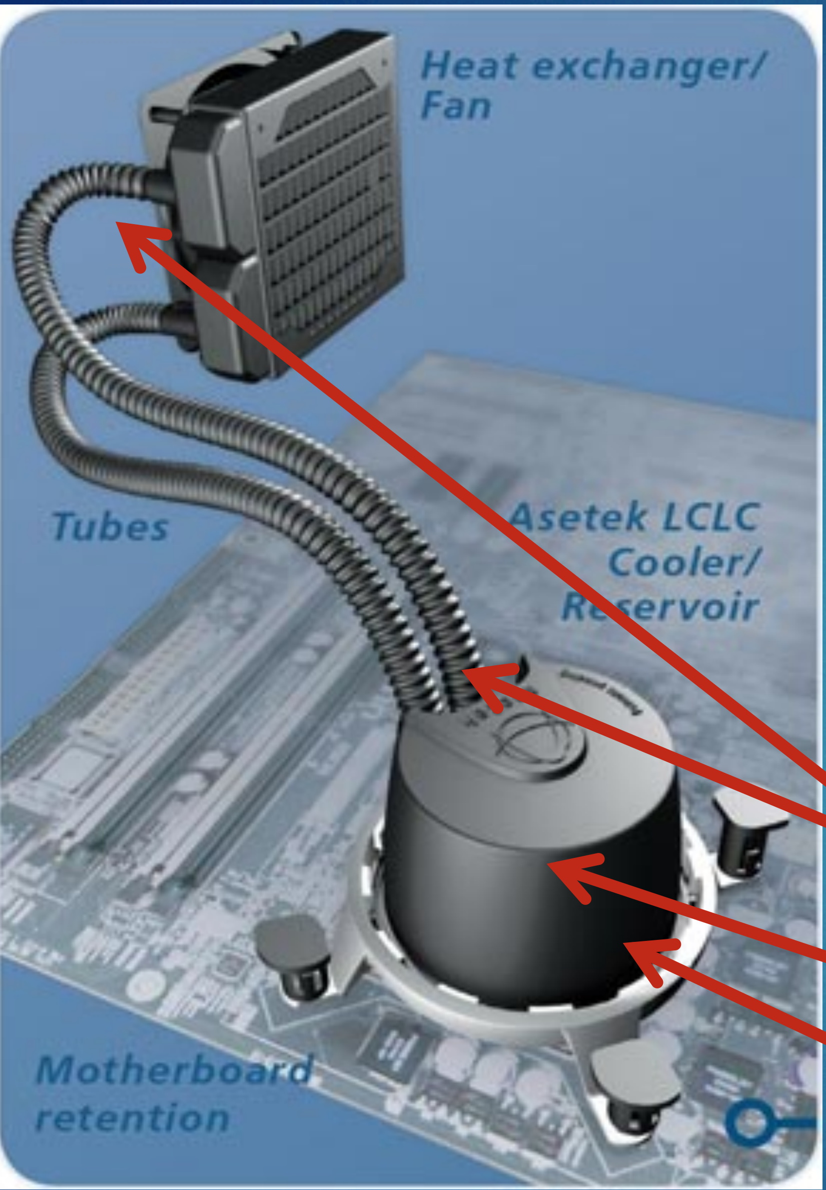
Liquid Cooling technology



3.Warm liquid is pushed by pump into the outlet tube a
Heads towards heat exchanger.

2. Heat transfers through cold plates into cooling liquid

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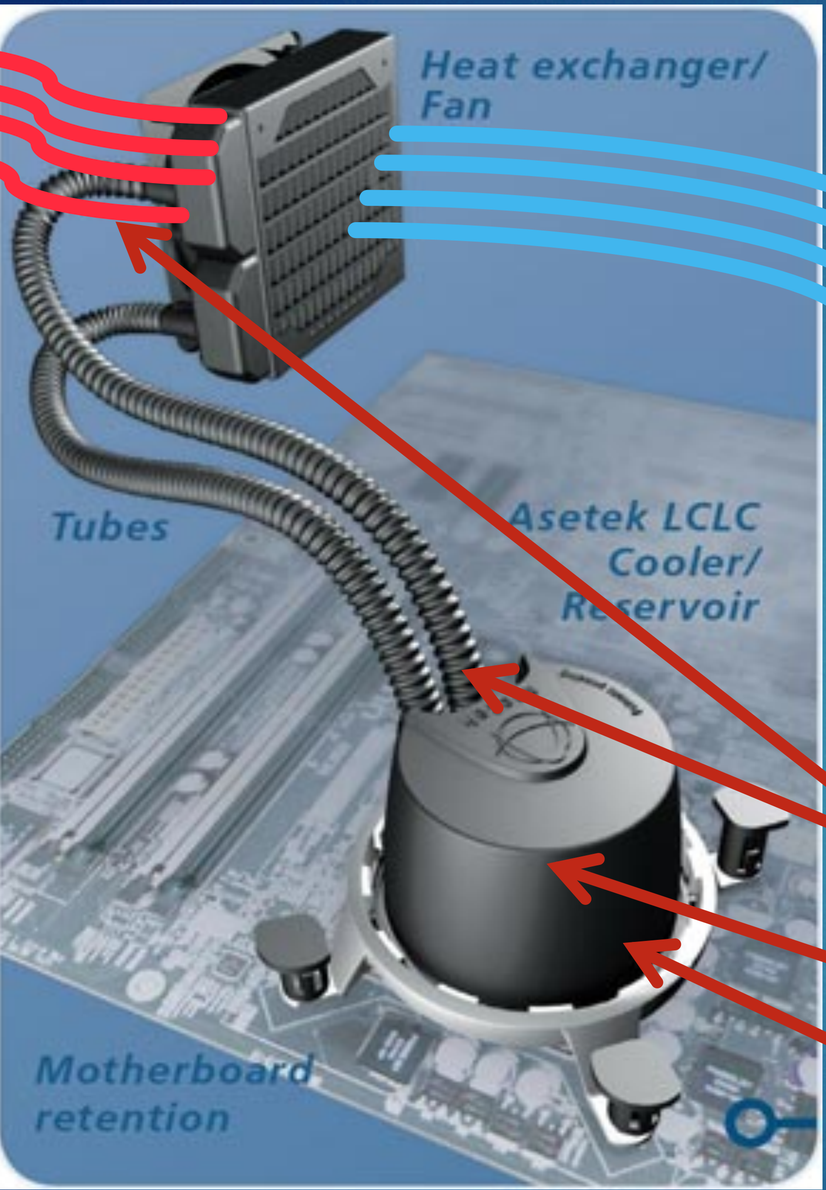
Liquid Cooling technology



4. The chassis fan creates a gentle breeze towards heat exchanger an heat from cooling liquid is transferre to breeze.

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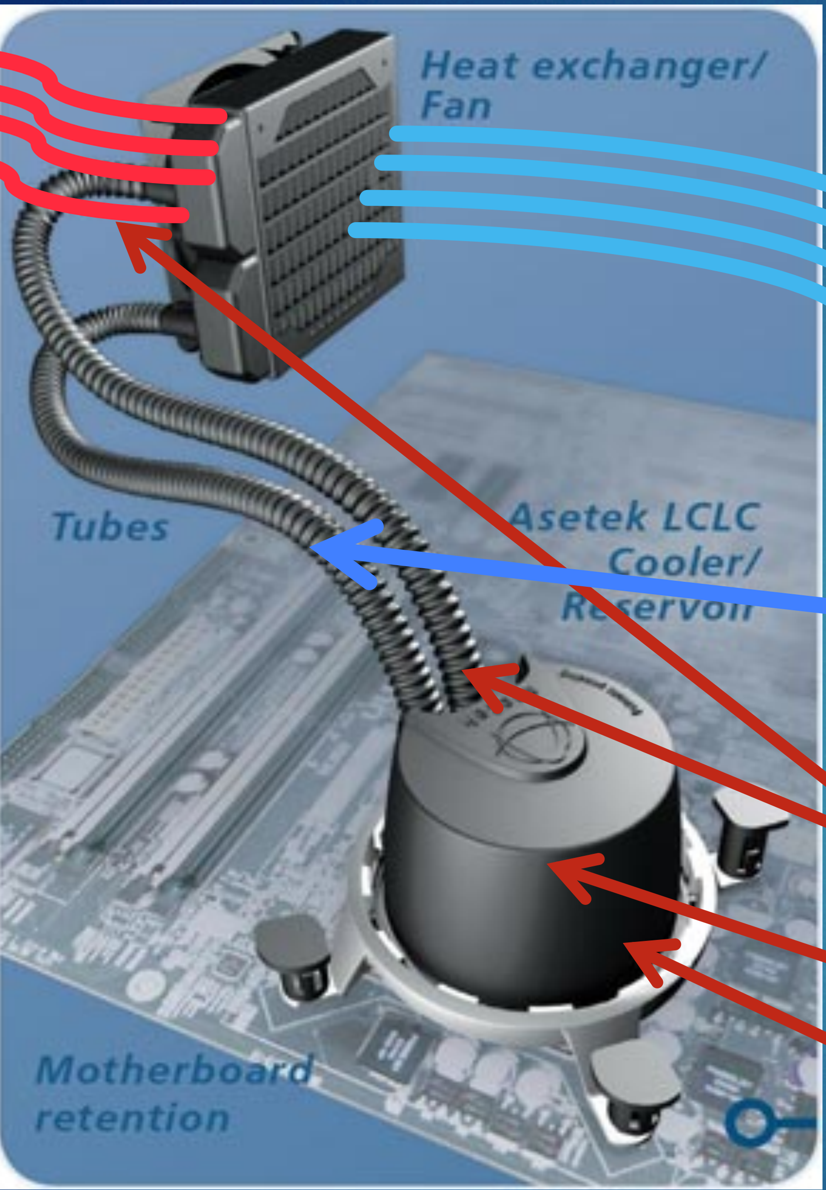

Liquid Cooling technology

4. The chassis fan creates a gentle breeze towards heat exchanger an heat from cooling liquid is transferre to breeze. And heat is removed.

5.Cooling liquid flows out of the heat exchanger and returns to the tube.

3.Warm liquid is pushed by pump into the outlet tube a Heads towards heat exchanger.

2. Heat transfers through cold plates into cooling liquid

1.CPU generates heat

Source:http://hothardware.com/Reviews/Asetek-Low-Cost-Liquid-Cooling-LCLC-System/?page=2

Liquid Cooling technology

Reasons to use water:

1. Cheap and nontoxic.
2. High thermal conductivity and specific heat capacity. (less volumetric flow and temperature difference)

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Liquid Cooling technology

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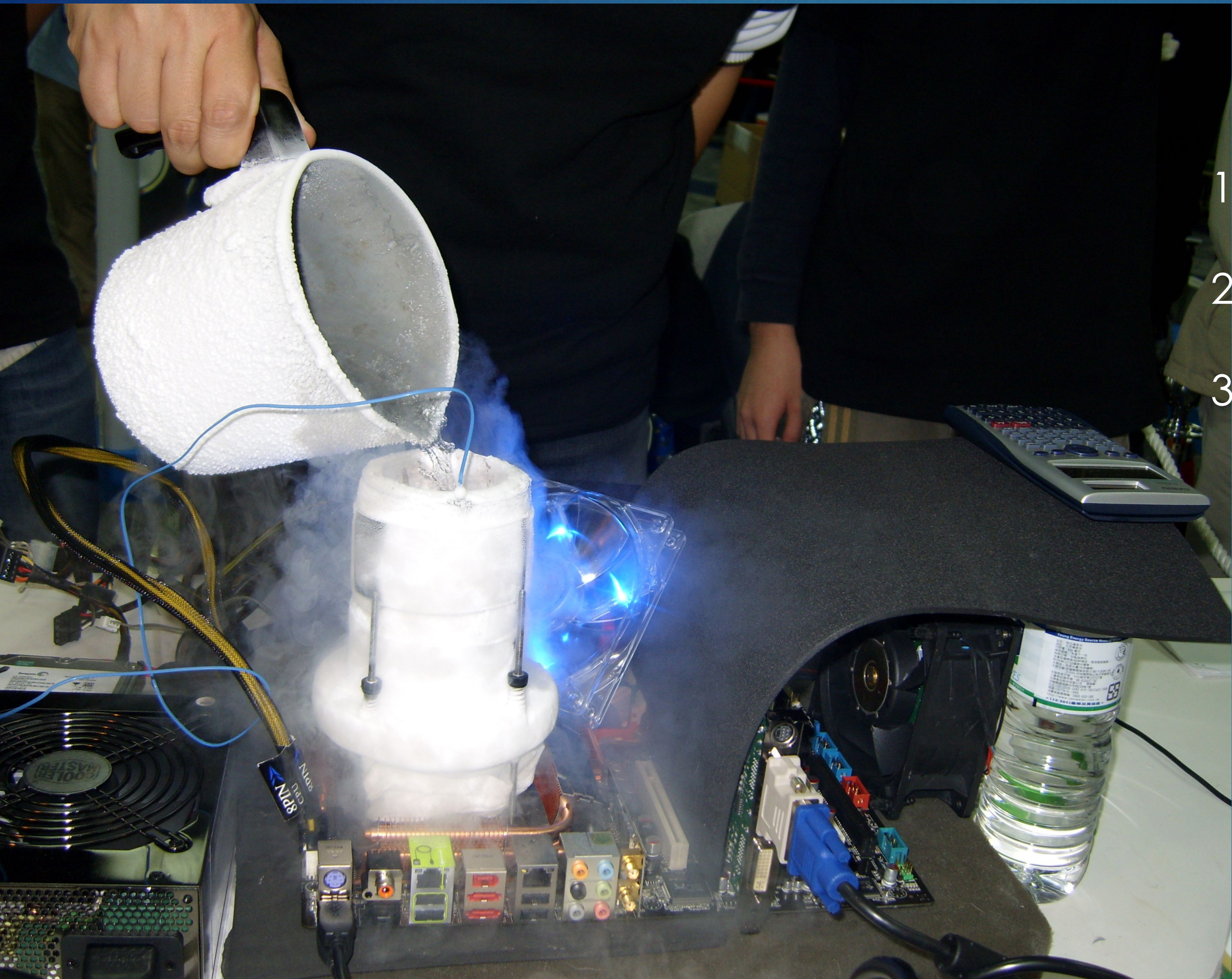
Disadvantage:

1. Deionized water is required.
2. Corrosive.
3. May cause short circuit.

Source:http://hothardware.com/Reviews/Asetek-Low-Cost-Liquid-Cooling-LCLC-System/?page=2

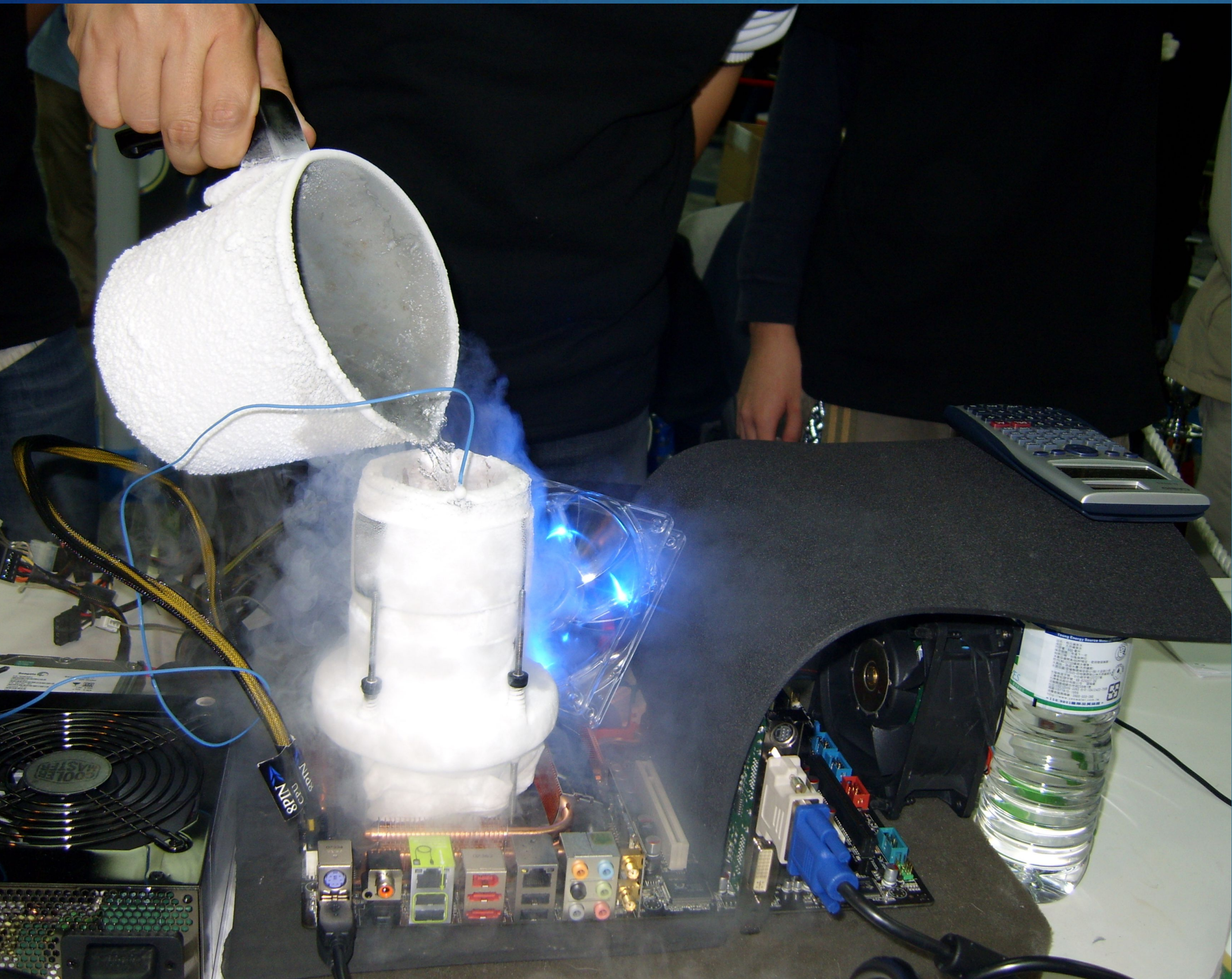
Liquid Nitrogen



rce:http://upload.wikimedia.org/wikipedia/commons/3/3c/2007TaipeiITMonth_IntelOCLiveTest_Overclocking-6.jpg

1. Extreme cooland for short overcloc Session.
2. A copper or aluminum pipe is mou on microprocessor and graphics co
3. Liquid nitrogen is poured into the p and resulting temperature is -100 C

Liquid Nitrogen



1. Needs refill after nitrogen evaporates– expensive.
2. Liquid nitrogen condenses oxygen and mixture of liquid oxygen and flammable material is explosive.

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