Innovative Manufacturing Technology Co.,Ltd.

세정기술워크숍

Dry Cleaning Techniques

Focused on Semiconductor & OLED applications

2006. 5

㈜ 아이엠티, 레이저그룹

이 종 명

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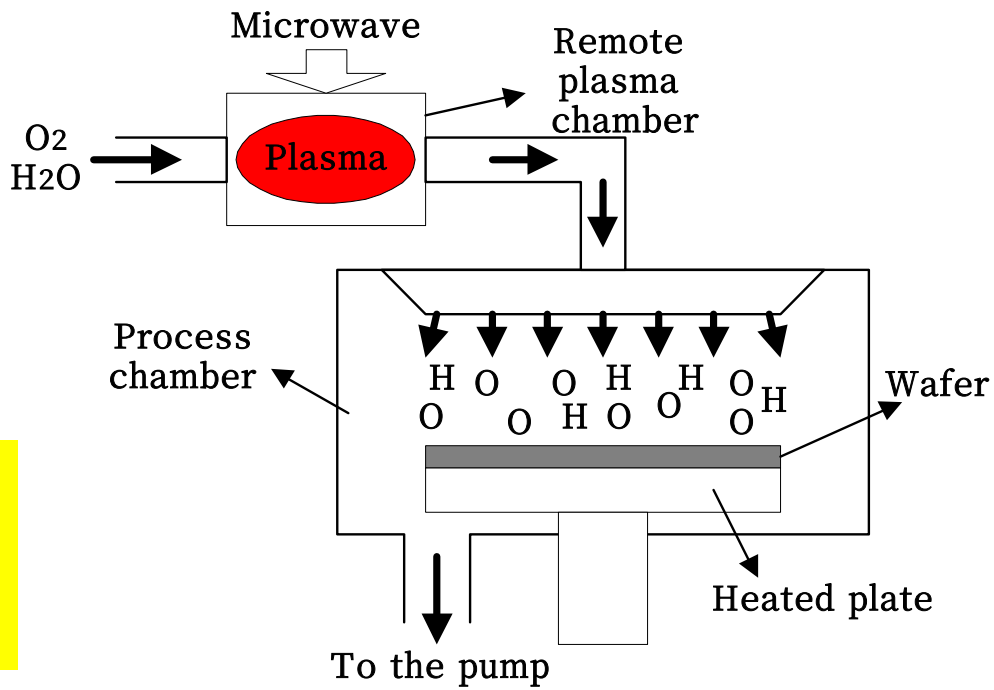
Dry Cleaning Techniques

- Limits of wet cleaning
  - > High aspect ratio structure (contact, trench)
  - > Water mark
  - > Corrosion issues (Cu, low-k)
  - > Cluster tool
  - > Environmental issues (water, chemicals)
- Plasma cleaning
- Dry ice cleaning
- Ar aerosol cleaning
- UV lamp cleaning
- Super critical fluid cleaning
- Laser cleaning
- Laser shock cleaning
- Laser plasma cleaning

Plasma cleaning (1)

- **Remote plasma cleaning**
  - > Ashing = PR stripping
  - > in-situ etch/strip processing
- **Direct plasma cleaning** : Reactive plasma & Ar plasma
  - > Ar plasma: pre-deposition cleaning by sputtering
  - > Reactive plasma:
    chemical reaction
    => volatile
    byproducts
    ex) PCB flux cleaning,
    desmearing,
    deflashing



***PR Stripping mechanism**

: chemical reaction

- O_2 => O+O, H_2O => 2H+O
- O + PR => H_2O+CO+CO_2 + ...

Plasma cleaning (2)

***Unique Characteristics**

>> Advantages:

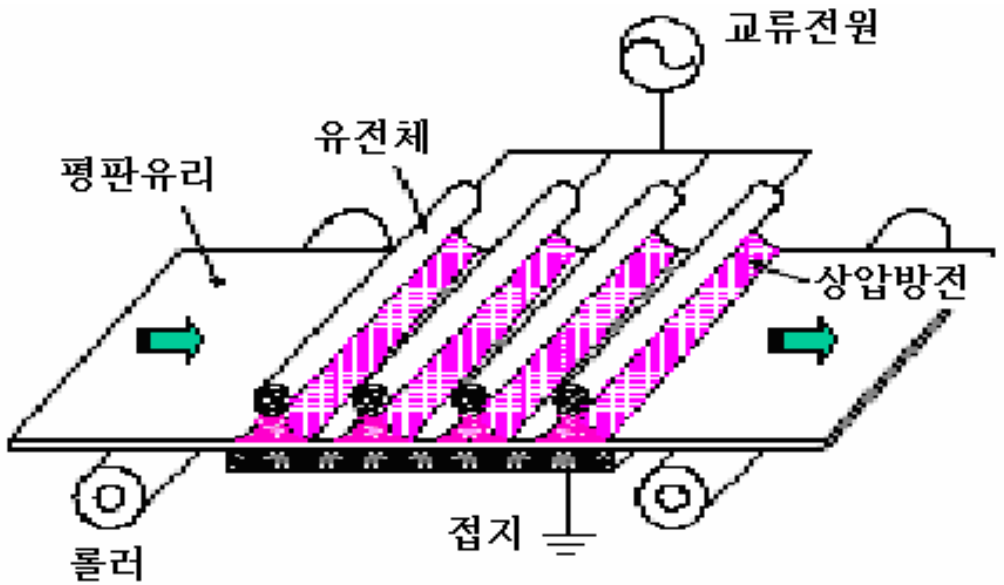
1) In-situ dry cleaning
2) No moisture effect => no metal corrosion
3) Good organic removal
4) Surface activation => good bond ability

>> Disadvantages:

1) poor inorganic & strong PR residue removal
2) Isotropic cleaning
3) Plasma charging
4) Non-feasible double-side cleaning

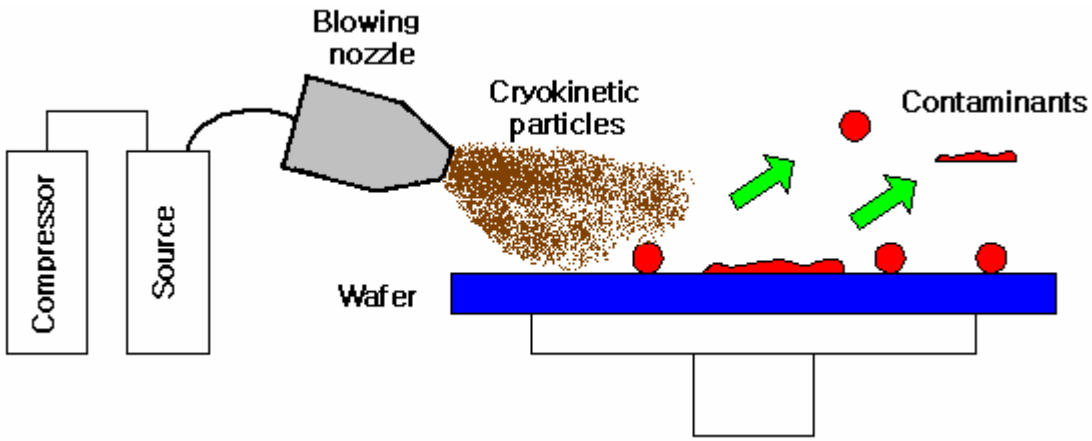
- **Atmospheric Plasma cleaning**
  - **> No vacuum**
  - **> Conveyer system**
  - **> Mass cleaning**
  - **> Only flat surfaces**

***Appl: FPD glass, pre-wiring & molding**



Dry Ice cleaning (1)

- Cryokinetic source: CO_2

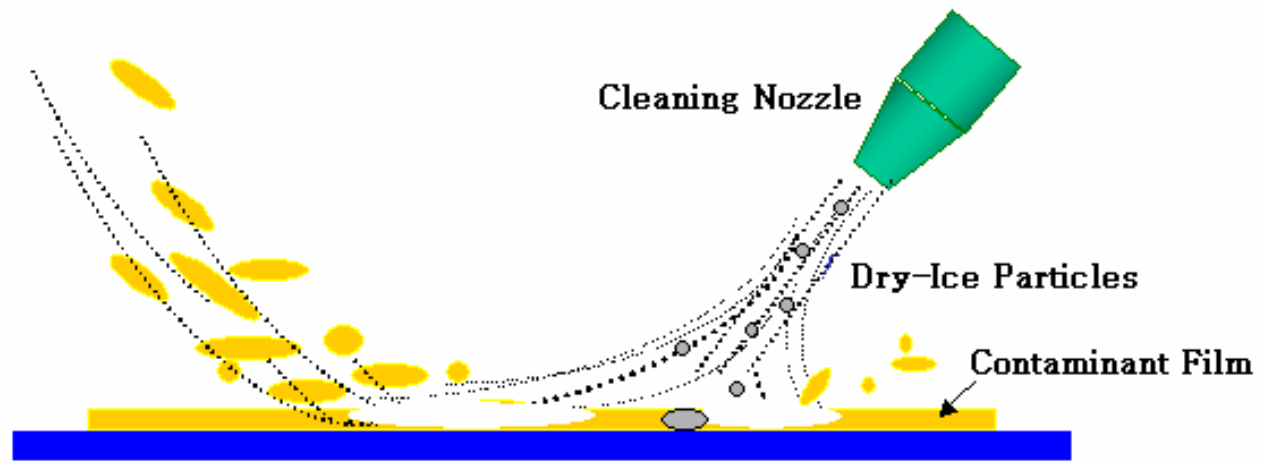


>> CO_2 dry ice pellets

>> Cleaning type

1. Soft dry ice cleaning = CO2 snow cleaning
   > liquid CO2 => adiabatic expansion at nozzle => dry ice generation and blowing
2. Hard dry ice cleaning = CO2 pellet cleaning
   > Dry ice lump => pellet => high pressure blasting

Dry Ice cleaning (2)



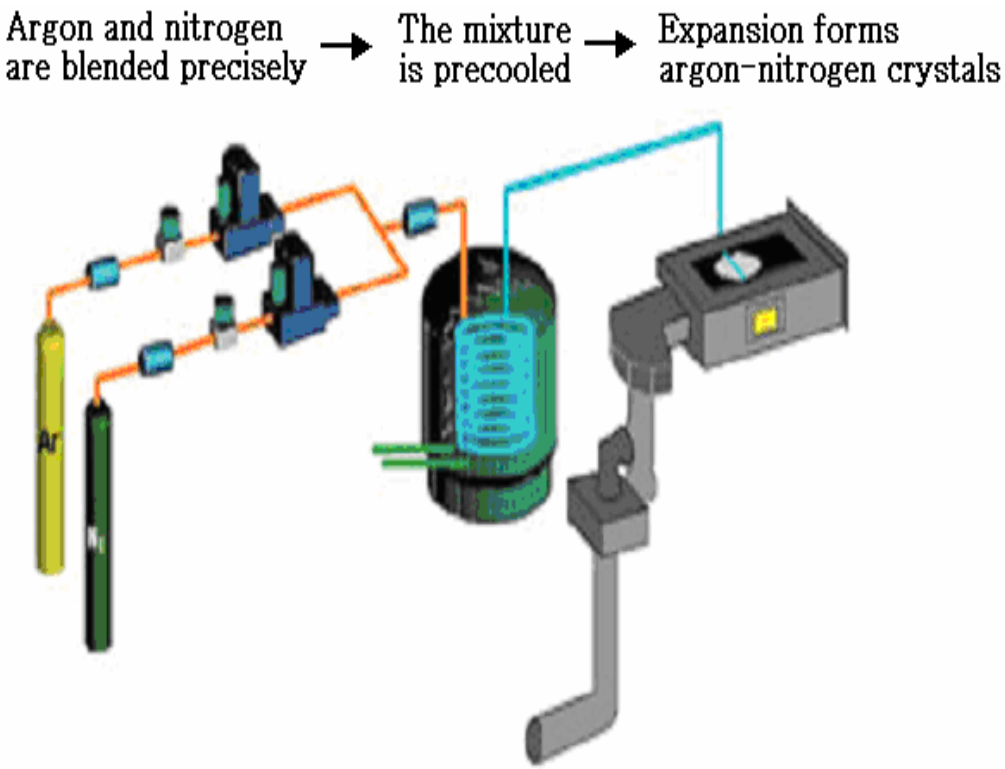
Source: KCTech

- Cleaning mechanisms
  - > Physical blasting
  - > Thermal shock (-78.7C)
  - > Sublimation expansion (x800)
  - > CO2 solubility: organic removal

- Applications
  - > Pellet : semi. equipment surface cleaning (Komico)
  - > Snow : FPD surface cleaning (KCTech)

Ar aerosol cleaning (1)

- Cryokinetic source: Ar
- Ar / N_2 mixture => compression => adiabatic expansion from the nozzle => Ar aerosol ejection

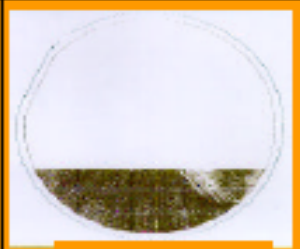
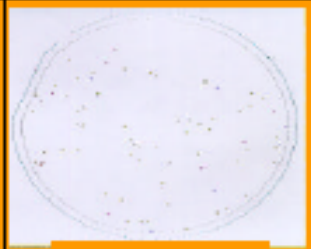
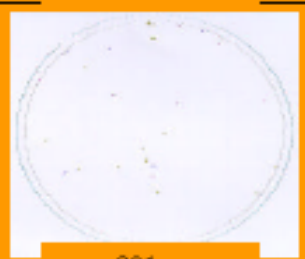


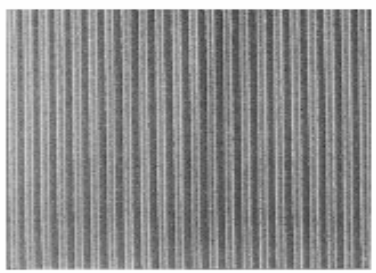
>> IBM patent technology => FSI International commercialized.

- **Advantages**
  - **1) Dry process**
  - **2) Excellent particle removal performance**
- **Disadvantages**
  - **1) Pattern damage => flat surface**
  - **2) Thermal shock**
  - **3) Expensive maintenance due to high purity Ar**
  - **4) Expensive equipment due to Vacuum process**

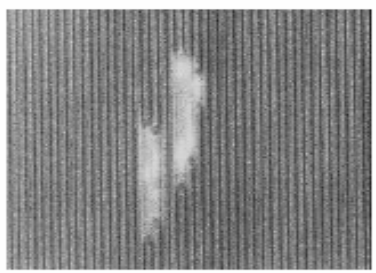
Ar aerosol cleaning (2)

- Cleaning performance

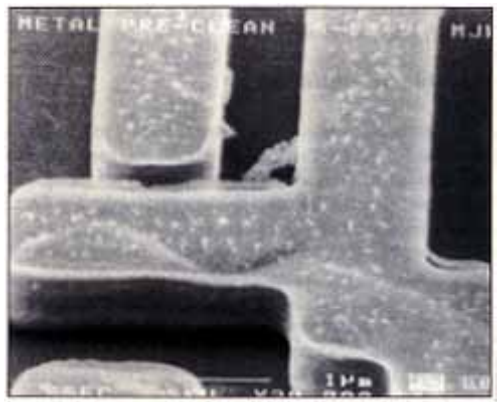
	Before cleaning	After cleaning	Efficiency
SiO_2 slurry on oxide	 Above 30000ea	 75ea	≥ 99%
Si3N4 particle on bare	 Above 30000ea	 301ea	≥ 99%

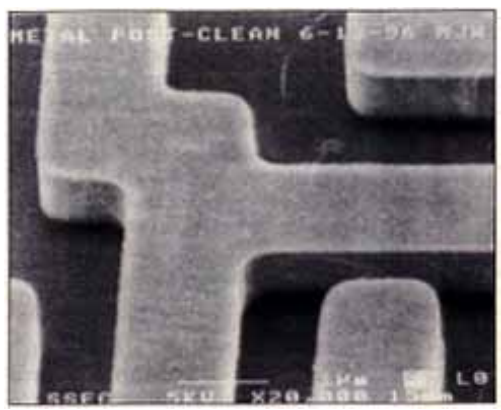


Accel. N2 = 0ℓ/min
(0.15㎛ poly line)



Accel. N2 = 15ℓ/min
(0.15㎛ poly line)

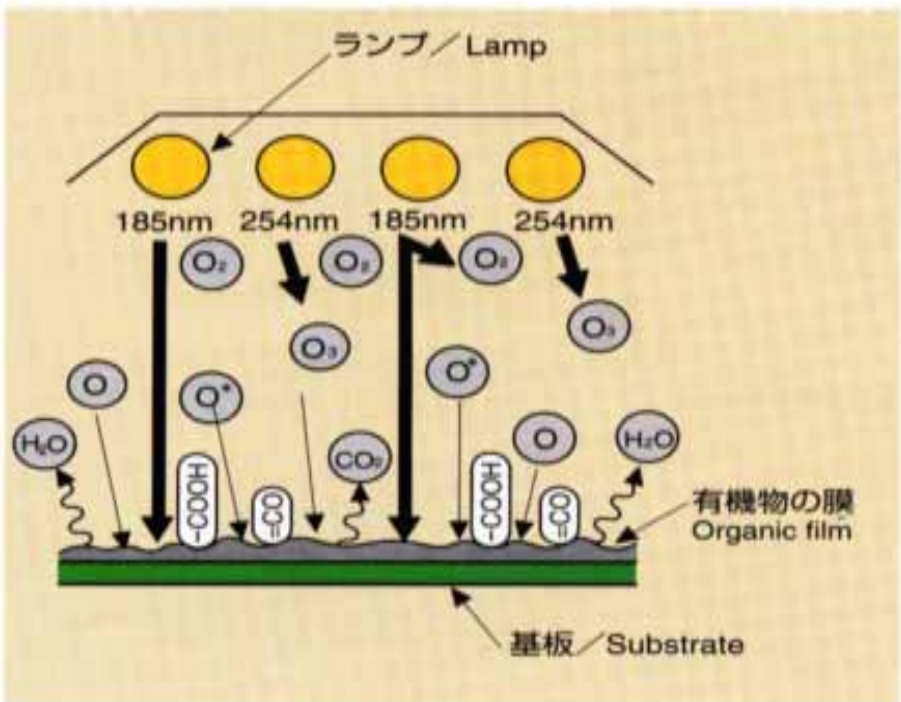




Corrosion removal on Al line

UV lamp cleaning

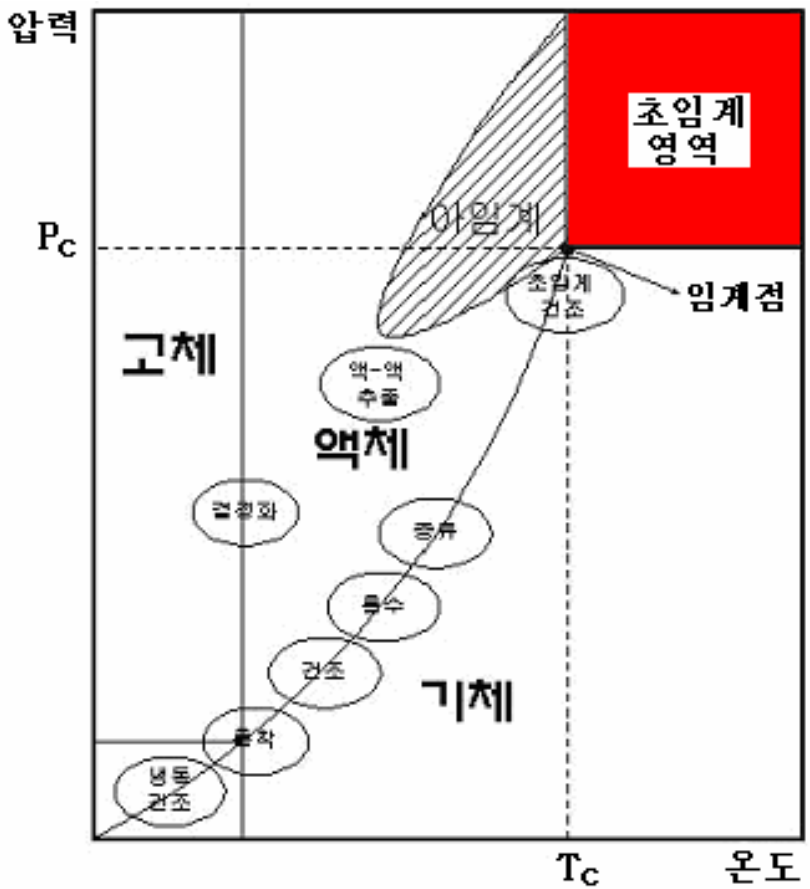
- UV radiation (Hg lamp) + O2 => O & O3 (O+O2)
- Mechanisms: Direct bond breaking + Chemical reaction
- E = hν = hc/λ
- Organic contamination removal (UV/O3 cleaning)
- Applications: PR hardening, OELD cleaning, surface activation



>> Competition with AP tech

Super critical fluid cleaning (1)

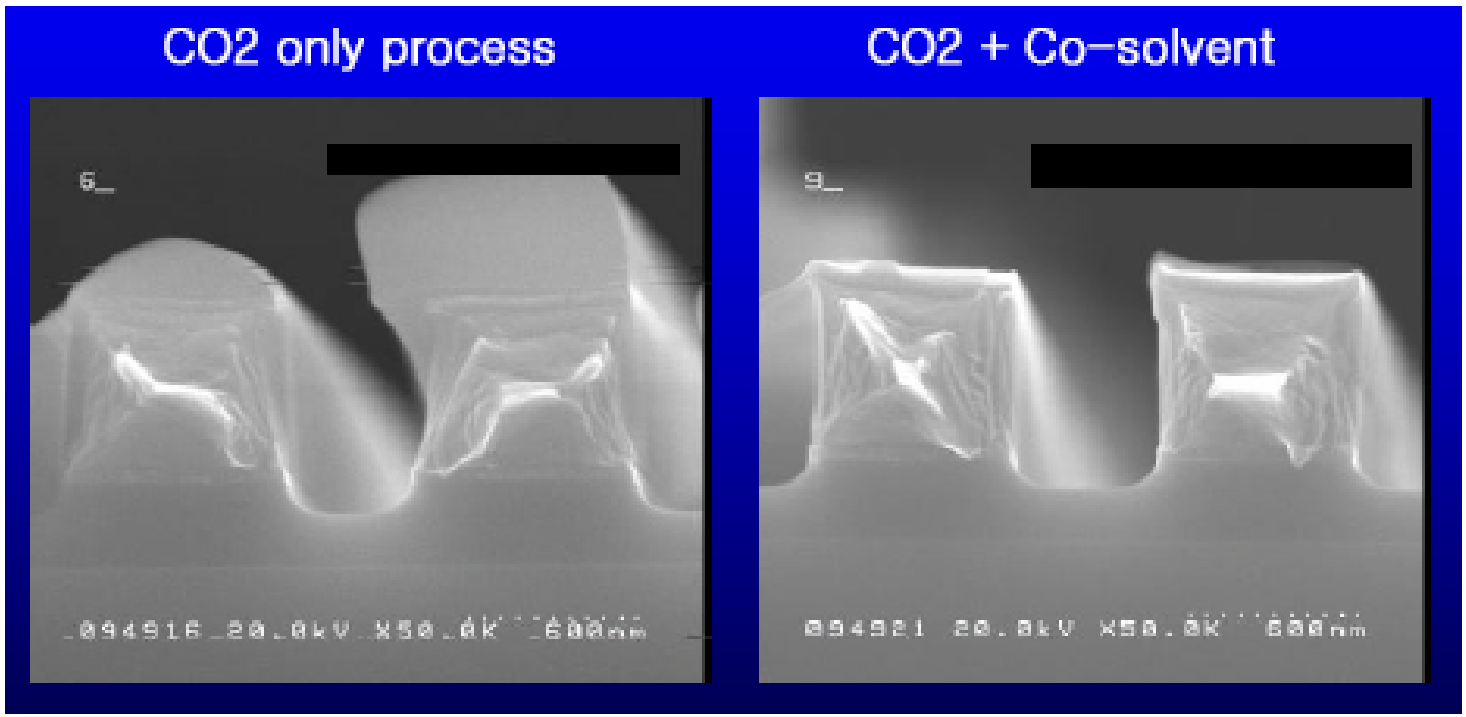
- Super critical region



- SCF characteristics (CO2)
  - > High density (~liquid)
  - > Low viscosity (~gas)
  - > High diffusivity (~gas)
  - > High solubility (CO2)
  - > Easy recycling
- Organic removal process
  - > PR removal
- Nano-scale pattern rinse & dry process
  - > Deep penetration

Super critical fluid cleaning (2)

- SCF Cleaning Demonstration



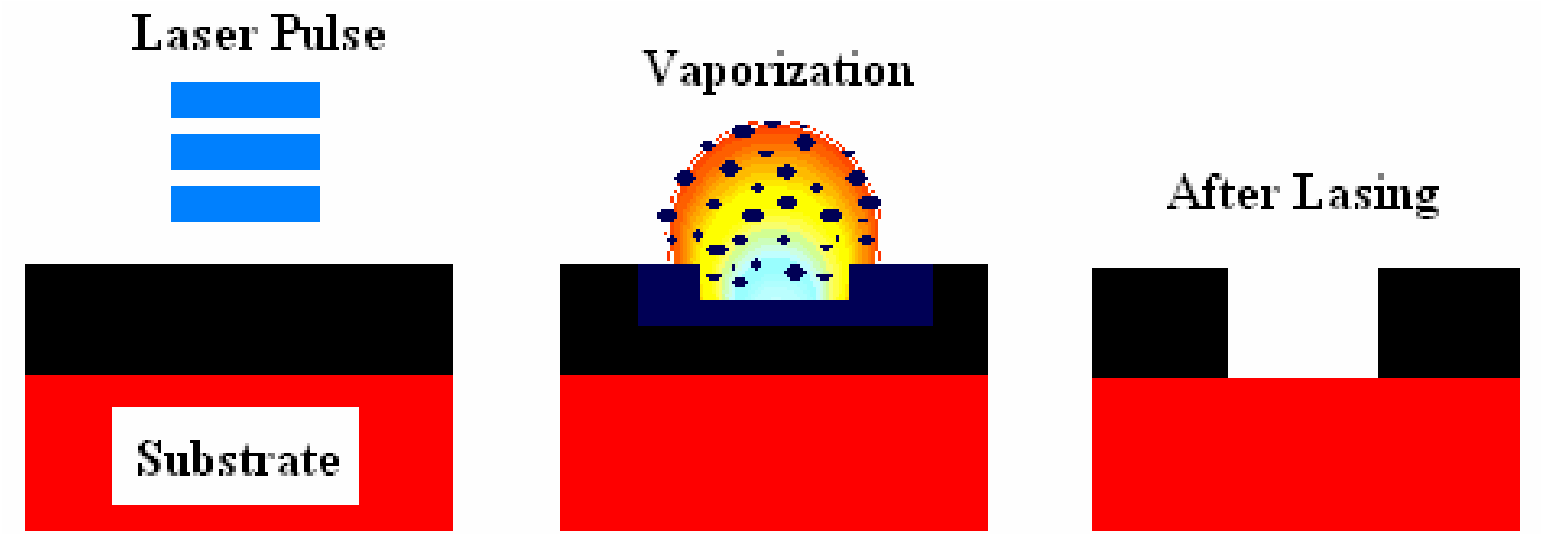
Source: K.T.Lee at Surface cleaning workshop, Boston

>> Co-solvent is essential to enhance the cleaning performance.

What is a laser cleaning?

- **Definition of laser cleaning**

  : A process which removes contaminants from a surface by laser-surface interactions



- **Cleaning mechanisms**

1. Photo-thermal effect
2. Photo-mechanical effect
3. Photo-chemical effect

Ref: *레이저와 청정가공,*
이종명저, 한림원, ***2002***

Process characteristics

- **Unique characteristics**

- Precise process which ceases shortly after the laser pulse has ended
- Selective process which can be tuned for the removal of specific substances with a proper selection of wavelength
- Non-contact process which produces no contact wear
- Surface relief process without any mechanical loads
- Controllable process that a specific thickness of materials can be removed
- Environmentally preferable (or clean) process since it is a dry process

Artwork conservation

(a) Initial appearance after excavation

First laser cleaning shoot at 1975, Venice

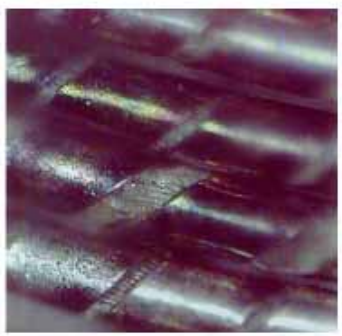
(b) After initial laser cleaning

(c) After completion of laser cleaning

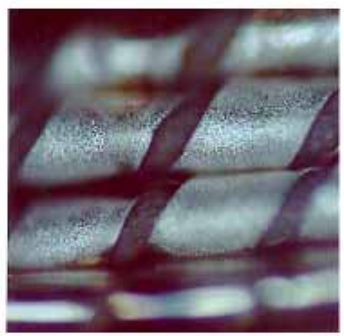
19C Swedish Royal Silver Textile

(a) Before laser cleaning

(b) After laser cleaning



Before cleaning



After laser cleaning

Medical applications

***Applications: Dermatology & Dental Surgery

Before treatment

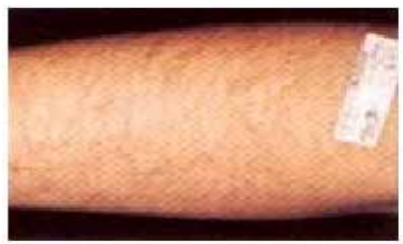
After treatment

Before treatment

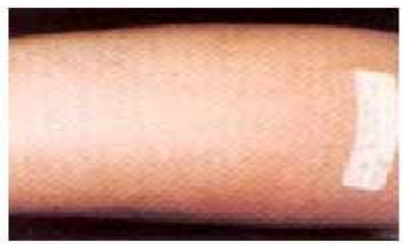
After treatment

Before treatment

After treatment



Before treatment

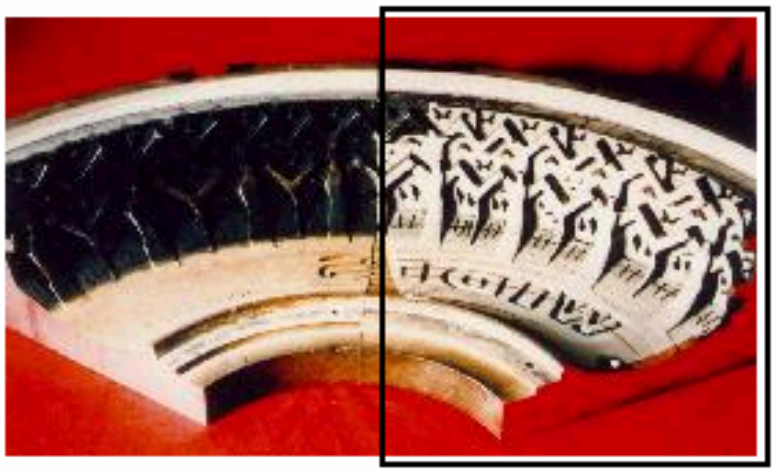


After treatment

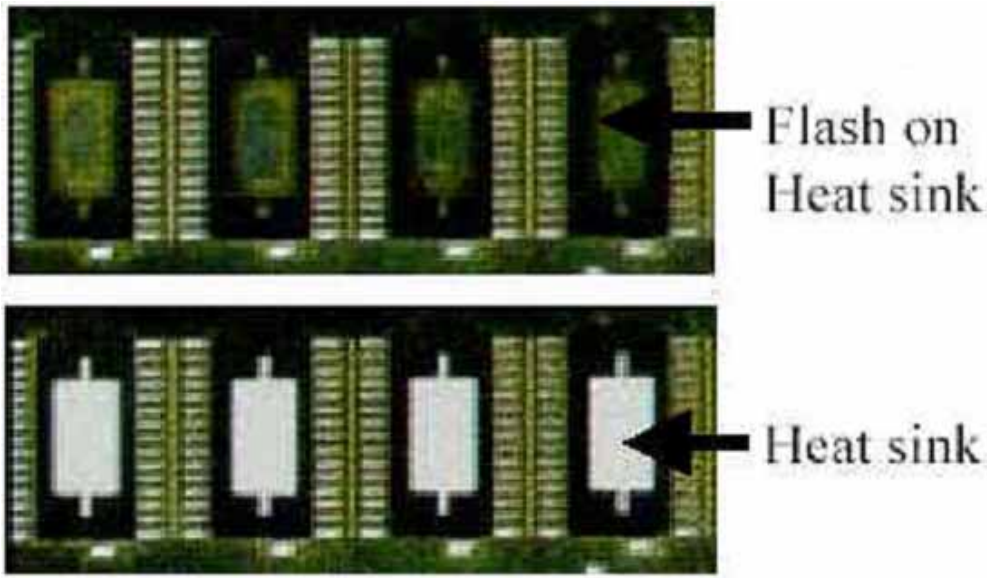
Before treatment

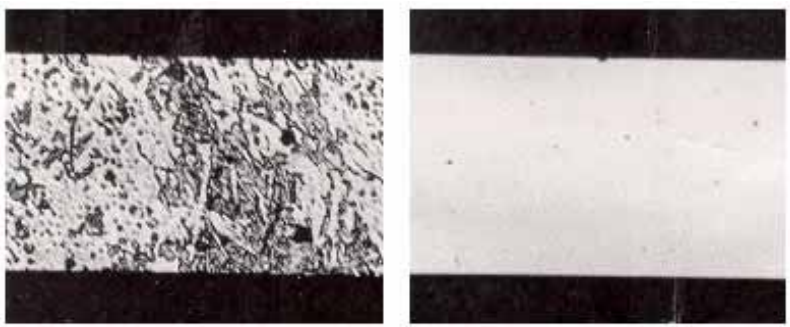
After treatment

Industrial applications

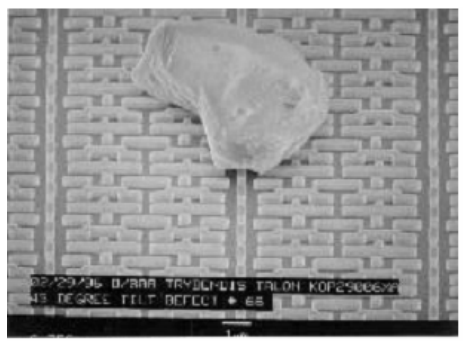


Uncleaned area Cleaned area

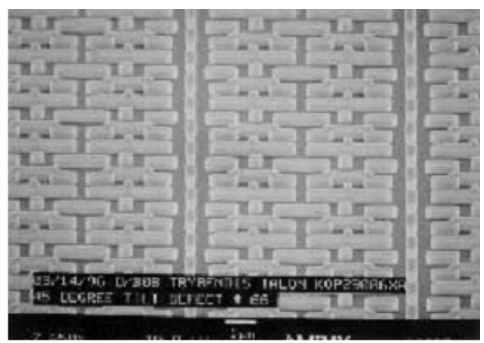




Before laser cleaning After laser cleaning



Before cleaning



After cleaning

Comparison of cleaning processes

	Media blasting	Dry ice cleaning	Wet chemical cleaning	Laser cleaning
In-situ cleaning (op. Off-line)	No	Yes	No	Yes
Labor required	High	Medium	High	Low
Level of automation	Low	Low	Low	High
Noise level	Medium	High	Low	Low
Substrate wear	Yes	No	Medium	No
Environmental hazards	Medium	Medium	High	Low
Post-cleaning waste	High	Low	High	Low

Summary

- Every cleaning methodologies have their own advantages and drawbacks, so fundamental understanding of the cleaning processes is most important for successful applications.
- Cleaning prospect (Semi. Industry)

  > Wet & Batch => Hybrid => Dry & Single
- Laser cleaning has unique characteristics and its industrial applications will be expand rapidly.
- iMT holds diverse laser cleaning techniques and systems, i.e. LSC, LPC, SLC, LMC, ISM etc.
- A creative idea from industrial fields is most important to implement the new technology successfully.