Panasonic
INDUSTRY

Plasma Cleaning

Technology and total process

Panasonic's parallel plate plasma chamber technology delivers superior etch uniformity compared to conventional batch-type plasma cleaner systems.

By using an argon plasma treatment, ultra-thin gold-plated electrodes can be more reliably wire-bonded without nickel compounds. The savings achieved through cheaper "flash-gold" plating can provide the ROI justification alone. The PSX307 Plasma Cleaner's other capabilities include:

> Surface modification by oxygen plasma
> Improving mold resin adhesion and under-fill wettability
> Reducing the incidence of peel-off, voids, and cracks

In addition, Panasonic's Plasma Monitoring System suppresses abnormal discharges, enabling a secure and efficient production process, and the option to include traceability functionality ensures high level process tracking.

PSX307 Plasma Cleaner

The PSX307 is available in 3 sizes: PSX307S, PSX307M and PSX307A.
> The S and M models are for substrates, with small and medium chamber size
> The A model is for substrates and wafers, with larger chamber size

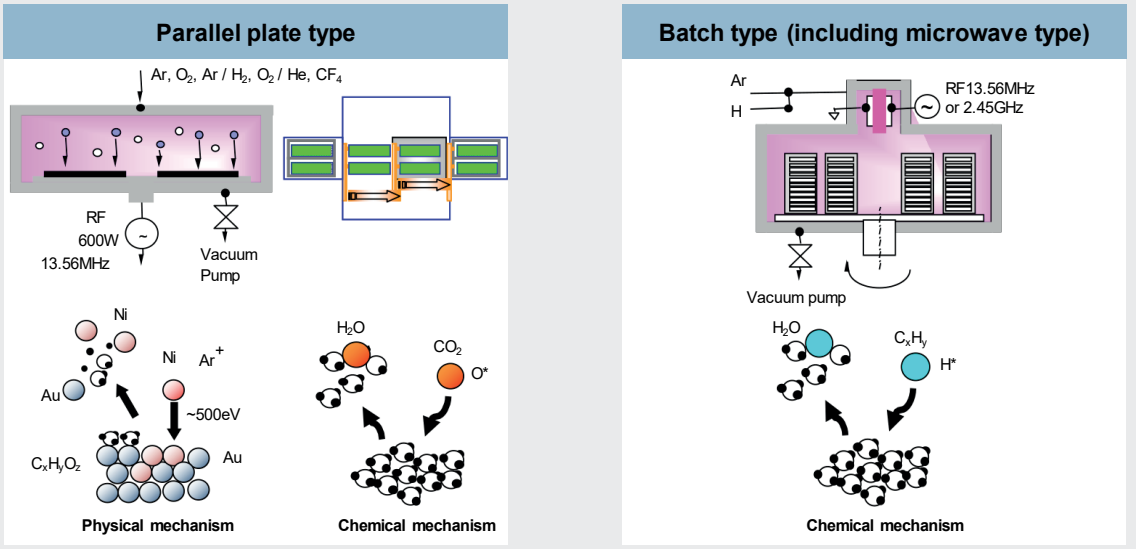
Panasonic's PSX307 Plasma Cleaner provides 50% higher productivity than conventional plasma cleaners.

PSX307 Plasma Cleaner Features

Parallel Plate Chamber Design

The PSX307 Plasma Cleaner chamber design is called "Parallel Plate Type". The operator sets the magazine into the loader, then the substrates are transferred into the chamber. Plasma cleaning is performed and the substrates are unloaded into the unloader magazine. Parallel plate cleaning offers better uniformity, and both physical and chemical methods of cleaning are effective.

The opposing technology is called "batch-type". The operator sets several magazines inside a chamber for a long time (20-30 minutes vs. 20-30 seconds). When compared with the PSX307, uniformity is not as good and only the chemical method of cleaning is active.

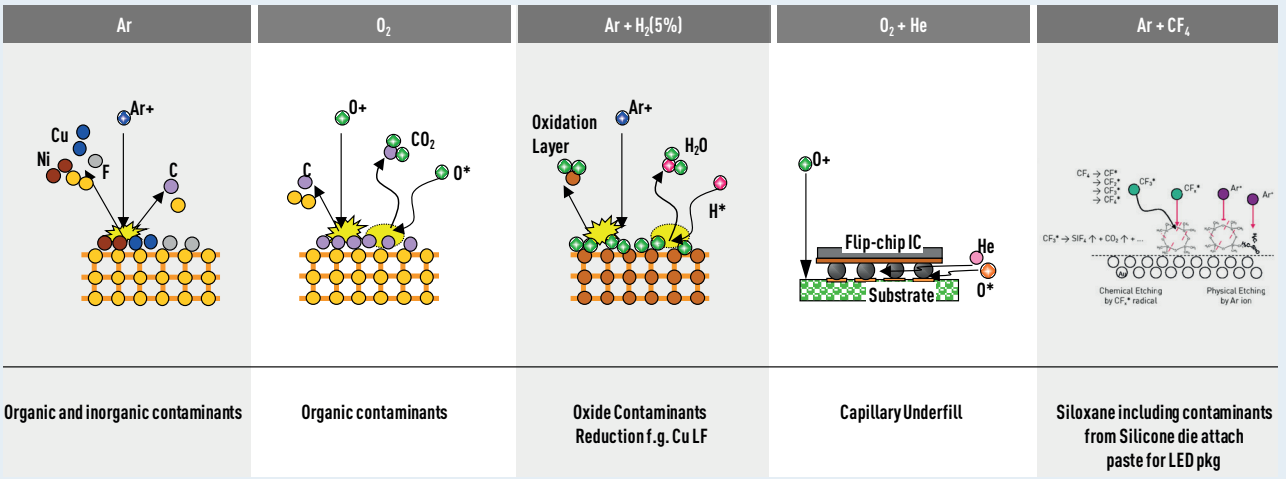


Comparison between Parallel Plate Type and Batch Type

Gas Mixtures

For plasma cleaning, the most popular gas is Ar. Ar can be used for both organic and inorganic contaminants. Physical bombardment using the kinetic energy of Ar ions is the main mechanism of plasma cleaning.

O_2 plasma is especially useful for removing organic contaminants. O_2 radicals react with C, forming CO and CO_2. O_2 should not be used for materials that will be oxidized easily such as Cu leadframes.



Panasonic's PSX307 can handle 5 kinds of gas

Ar and H_2 mixed gas is recommended to clean oxide contaminants such as CuO of Cu leadframes, because hydrogen reacts with oxides to form H_2O. The water molecules will be easily pumped away. Together, the physical ion bombardment of Ar and the chemical reaction of hydrogen are used to remove contaminants. O_2 and He mixed gas are recommended to improve capillary underfill for the best wettability in tiny gaps.

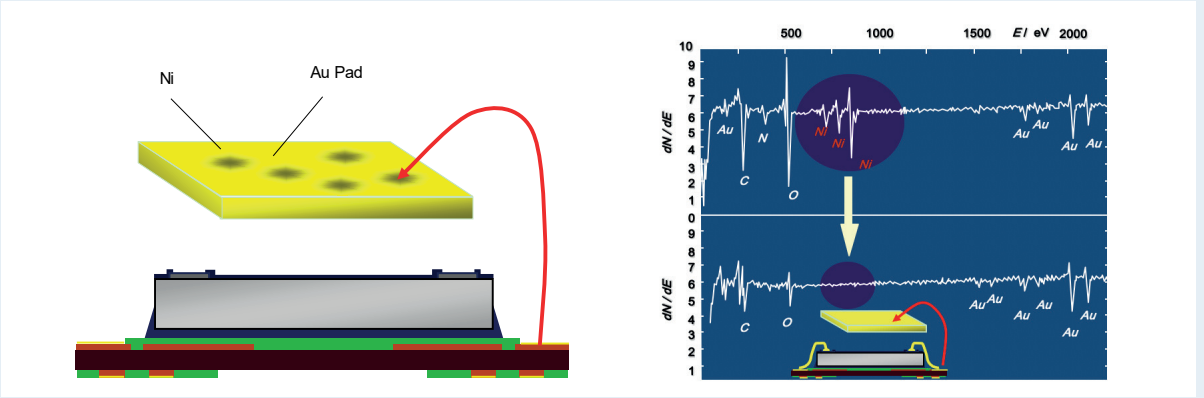
O_2 radicals modify the surface between the chip and the substrate and He helps the O_2 radicals travel through the narrow gap, as He is a very light and small element.

Ar and CF_4 mixed gas are used to remove siloxane contaminants in LED packages. Pure Ar plasma cannot remove Si-containing materials. This gas mixture is recommended as CF_4 reacts with Si to make SiF_4, which is a volatile material.

PSX307 Cleaning Applications

Case 1: **Wire Bonding Process on Au Pad**

Issue: Poor bonding quality and stability
Solution: Remove Ni diffusion compounds or organic contaminants



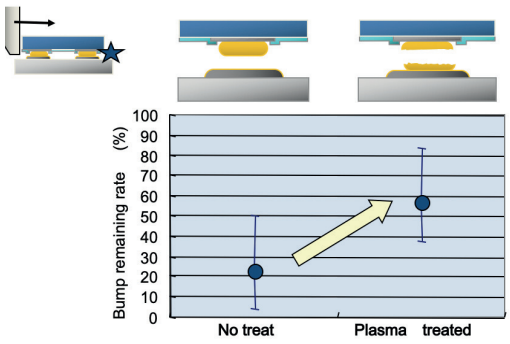
Improve bonding strength and achieve bonding stability

This is the most popular application of plasma cleaning. Plasma cleaning improves wire bonding ability by removing surface contamination on gold-plated pads. In case the Au layer is very thin and under-bump-metallization is without a diffusion barrier, Ni underneath Au migrates to the top of the Au surface and creates Ni compounds. These Ni compounds reduce wire bonding quality. Plasma cleaning can remove Ni compounds and realize excellent shear values. It will also result in significant changes in failure mode at bump or die shear.

Case 2: **Improve Flip-chip Bonding with Au-Au**

Issue: Poor Gold-to-Gold Interconnect bondability (e.g. wire bonding or TSB / Flip-chip Bonding)

Solution: Remove contaminants from bump surface on die and Au pad substrate



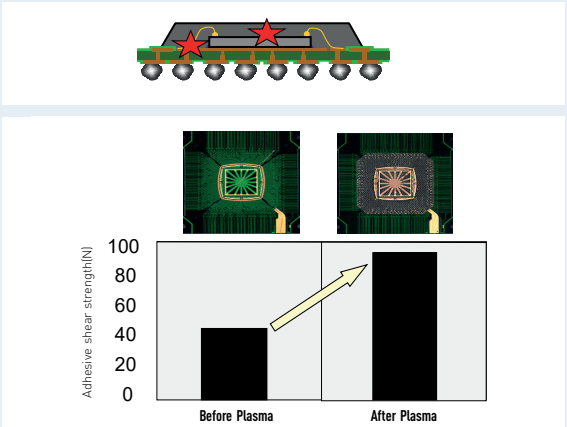
Achieve 3x higher shear strength or even changed failure mode, and high quality GGI and GCI bonding

Plasma cleaning also improves gold-to-gold interconnect flip-chip bonding reliability. The method of improvement is the same as in the case of wire bonding. Plasma cleaning can remove contaminants on Au pads and improve bonding quality.

Case 3: **Improve Molding Adhesive Ability**

Issue: Poor mold adhesive ability with lead-free and RoHS compliance

Solution: Surface modification before molding process by changing the wettability of the surface



Achieve double the adhesive ability of mold compound. Prevent mold delamination and improve moldability

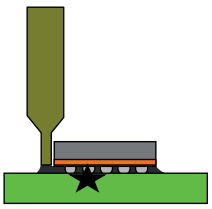
Plasma can also enhance the adhesivity between molding resin and the substrate surface. Adhesive shear strength is greatly increased after plasma treatment is performed.

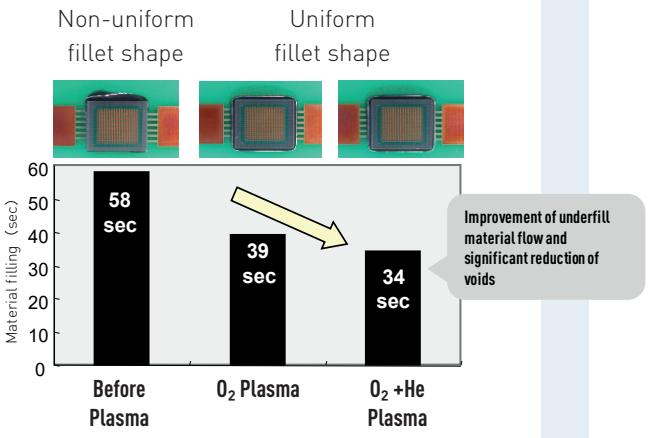
Case 4: **Improve Capillary Underfill Process**

Issue: Difficulty of underfill process for big size and high pin count flip-chip package

Solution: Surface modification in flip-chip gap by oxygen plasma before underfill process

Die Size = 7.2 x 7.2 mm
Gap = 65 µm
I/O = 144
Bump Pitch = 400 µm



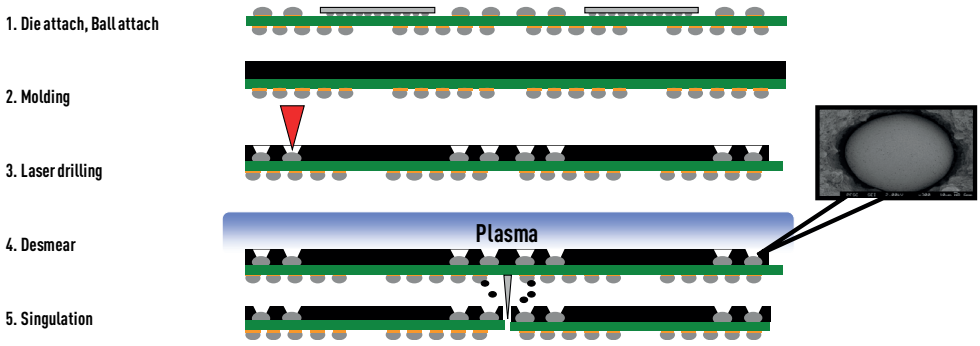


Underfill time can be reduced by 40% and achieve high quality underfill process. "Uniform fillet shape, Void-free"

For large or high pin count chips it is difficult to achieve a good fillet shape and underfilling takes a long time with high risk of low adhesion and potential occurrence of many voids. O_2 and He mixed gas plasma is especially useful in these cases. O_2 radicals can travel through narrow gaps between the chip and the substrate to modify the passivation and substrate surfaces. As a result, underfilling times can be shortened. Void-free and delamination-free flip-chip packages can be achieved.

Case 5: **Desmear Process after Laser Drilling**

Issue: Improve PoP bonding quality with TMV package
Solution: Ar plasma is used to remove smear residue after laser drilling

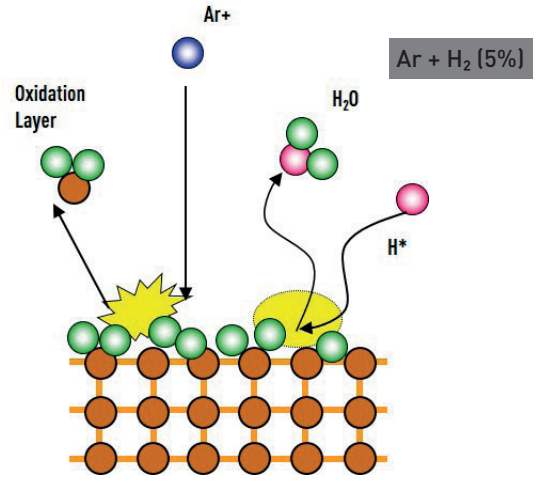


Plasma process desmears laser vias and improves PoP bondability

In the case of PoP (package on package) processes, plasma cleaning contributes to improved bonding quality. It can remove debris and smearing after laser drilling processes and realize good contact quality for PoP stacks.

Case 6: **Copper Cleaning**

Issue: Cu leadframe oxidation
Solution: Ar and H_2 mixed gas can remove contaminants such as CuO of Cu leadframes because H_2 can react with oxide and makes H_2O



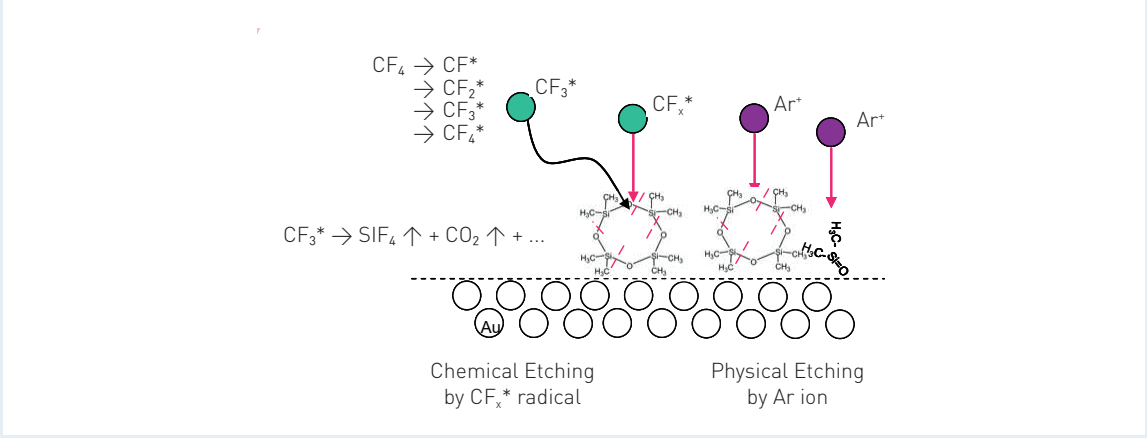
Physical ion bombardment of Ar and chemical reaction of H are used to remove contaminants

In order to remove oxide contaminants such as CuO of from Cu leadframes it's recommended to use an Ar/H gas mixture. H reacts with oxide to form H_2O, and Ar in parallel performs the physical ion bombardment to remove other contaminants.

Case 7: **Removal of Siloxane**

Issue: Degrading of wire bonding by Siloxane coming from silicone die bonding paste

Solution: Pure Ar plasma cannot remove Si containing materials, so CF_4 gas mix is recommended. CF_4 reacts with Si to make SiF_4, a volatile material



Improvement of bondability by using CF_4 plasma to remove siloxane contaminants on the Au pads

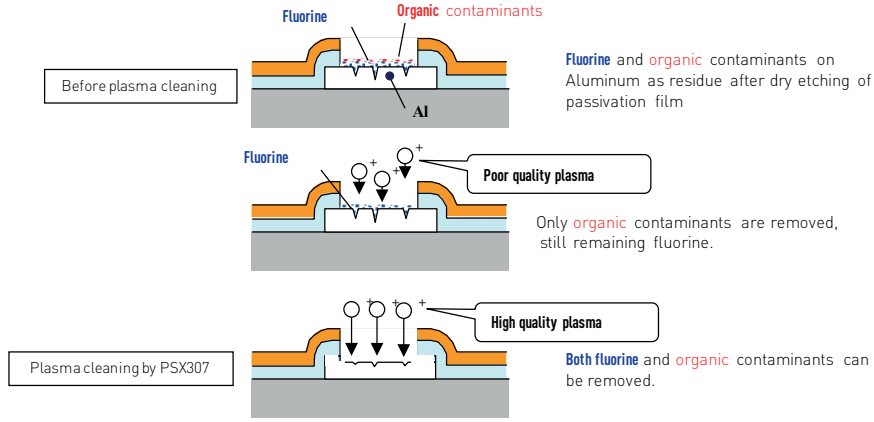
Silicone-based die bonding paste is often used in LED packaging processes and these silicone and siloxane contaminants are difficult to remove by conventional Ar plasma treatment. In this case an Ar/CF_4 mixed gas plasma cleaning is used to remove silicone and siloxane contaminants effectively.

CF_4 reacts with Si and forms SiF_4, which is volatile. By mixing this with the Ar ion physical bombardment effect, not only can silicone and siloxane contaminants can be removed, but also wire bonding ability can be improved.

Case 8: **Flourine Removal**

Issue: Bonding reliability due to existing F on Al-pad, especially in the case of Cu-wire bonding

Solution: Removal of F by high quality plasma cleaning



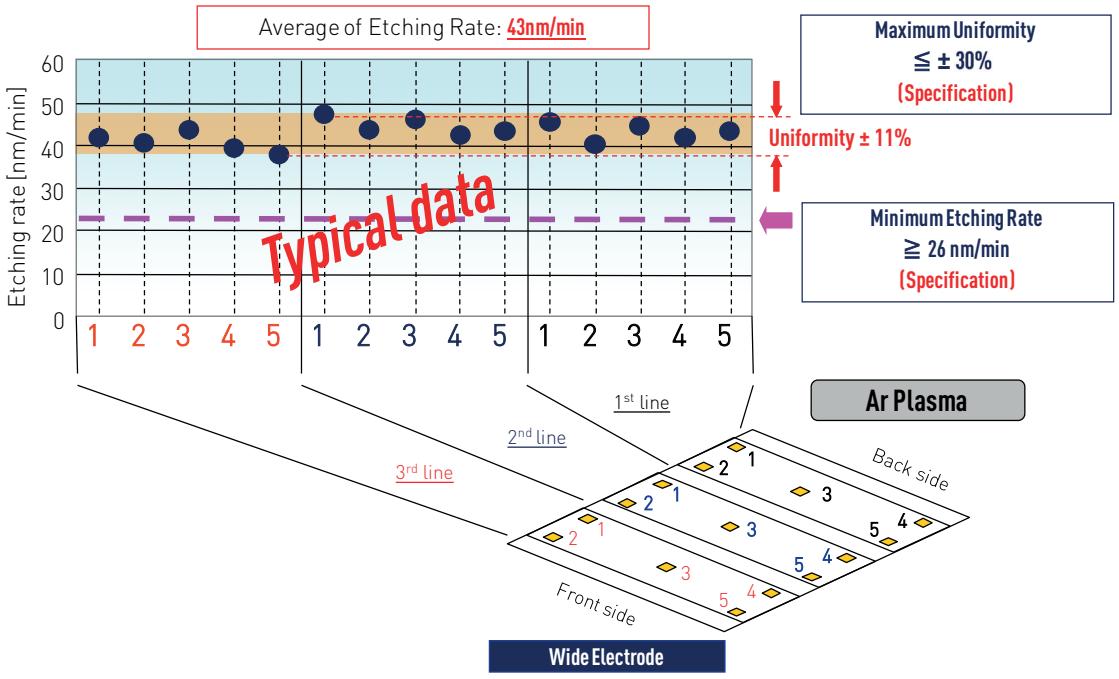
Improvement of bondability by eliminating not only organic contaminants but also F. Plasma cleaning leads to extended lifetime of the interconnect between bonding pad and bump.

Cu wire bonding has gained in popularity due to the cost benefits compared to Au wire bonding. In this case, F residue could be detrimental to Cu wire bonding because F residue interferes in making Cu-Al inter-metalic compounds. Plasma cleaning can remove the F residue by high power Ar plasma treatment and realize excellent Cu wire bonding reliability.

Uniform Etching Quality

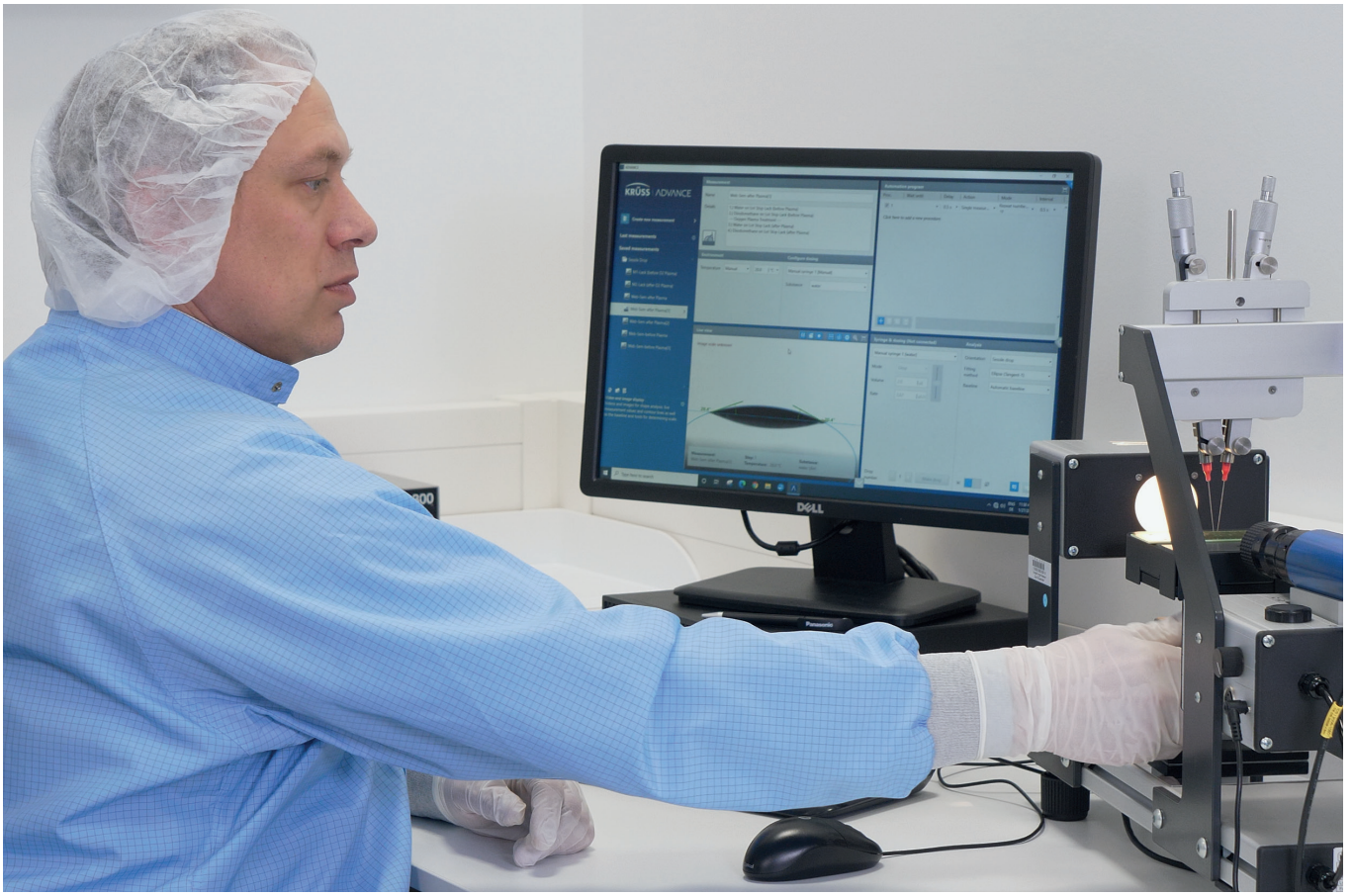
The PSX307 S-type minimum etching is specified by Panasonic to be over 26 nm/min. The PSX307 S-type's average etching rate is 43 nm/min and its uniformity is ±11%.

The data below show the etching performance of gold plating using the PSX307S



Good uniformity over the entire electrode area ensures excellent quality on large multi-pattern substrates, multiple loaded carriers, or large wafers

Demo Centers in Munich and Osaka



Panasonic has demonstration centers in Munich, Germany and Osaka, Japan.

Panasonic can perform demonstrations with the **PSX307S**, **PSX307M** and **PSX307A** plasma cleaner models.

To analyze the effectiveness of plasma cleaning, several measurement devices are available. An XPS (X-ray photoelectron spectroscopy, also called ESCA - Electron Spectroscopy for Chemical Analysis) system is available for surface analysis of substrate and wafer surfaces. An SEM (Scanning Electron Microscope) to investigate the surface before and after plasma cleaning treatment is also available.

To measure Au and photo-resist thicknesses, Panasonic have two etching rate measurement machines.

- In the case of Au plating thickness measurement, an X-ray fluorescent film thickness measurement system is offered. The Au plating etching rate can be calculated by measuring the thickness before and after plasma cleaning treatment.
- In the case of photo-resist thickness measurement, a nano spec optical film thickness measurement system is offered.

In addition, a water droplet contact angle measurement system is available. After plasma treatment, the contact angle made by water on the surface is decreased. The plasma cleaning effect can be seen with this equipment very easily.

If you wish to arrange a demonstration, please contact us.

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