Tergeo plasma cleaners O2 plasma photoresist stripping/ashing and descum

Unique feature #1: Direct and downstream cleaning modes in one system



Direct mode: Faster and more directional

Capacitively coupled plasma

Direct/immersion mode plasma cleaning

Plasma is generated in sample chamber Samples are immersed in the plasma. Samples are subject to chemical reaction with radicals and energetic ion bombardment.

Downstream mode: Gentler and isotropic



Remote/downstream mode plasma cleaning

Plasma is generated outside sample chamber. Samples are not immersed in energetic plasma Only gentle chemical reaction takes place on sample surface.

No energetic ion sputtering. No sample surface damage due to excessive heating, charging and ion bombardment. No damage to sensitive devices!

Unique feature #2: Quantitative plasma intensity sensor technology



Direct/immersion cleaning mode

Remote/downstream cleaning mode



Plasma generated in the sample chamber. Plasma intensity reading is 206

Plasma generated in the remote plasma source. Plasma intensity reading is 170

Take the guesswork out of plasma cleaning. Plasma sensor tells the user exactly how strong the plasma is. User can use the quantitative plasma intensity measurement as feedback to adjust gas flow rate and rf power for desired cleaning speed. **Plasma emission sensor can also be used to monitor the progress of complete photoresist stripping.**

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O2 plasma ashing for hard baked photoresist



Tergeo-plus, 150W rf power, 4-inch wafer Shipley 1813 positive resist, cured Speed can be further reduced at lower power or pulse mode for descum. <u>Gentle downstream mode is also available as an upgrade option</u>

O2 flow rate (sccm)	3	5	5	10	20	30
Argon flow rate (sccm)	0	0	5	0	0	0
Chamber pressure (mTorr)	65	92	123	157	250	336
Plasma intensity reading	298	263	820	210	157	144
Etching speed (nm/min)	186.57	231.17	183.00	160.20	97.20	34.60

Plasma emission intensity reading



Tergeo plasma system can measure plasma emission light intensity. The plasma emission light can vary a lot with different gas species. During O2 plasma photoresist ashing process, it can generate CO, CO2, H2O type byproduct, which can change the plasma emission intensity a lot. Therefore, it's possible to monitor the progress of the ashing process by monitoring the plasma emission intensity.

Courtesy of the Biomolecular Nanotechnology Center, UC-Berkeley

Photoresist stripping with plasma emission sensor monitoring

Shipley 1813 photoresist ashing curve in 150W Tergeo-plus



Plasma emission intensity reading indicates the partial pressure (density) of the ashing byproduct in the plasma chamber. The higher the plasma emission intensity, the more the ashing byproducts exist in the chamber. When the photoresist has been completely removed, the density of the ashing byproducts (CO2, CO, H2O) will be reduced to almost zero. Then the plasma emission intensity will be reduced to pure oxygen level. Therefore, it's possible to monitor the ashing end-point by monitoring the plasma emission intensity.

PMMA resist descum experiment



-- 100Watt, downstream mode, 10sccm O2, Rate: 10.7nm/minute

-50Watt, downstream mode, 10sccm O2, Rate: 4.3nm/minute

Courtesy of the Center for Quantum Devices at Niels Bohr Institute, The University of Copenhagen, Denmark

Etching/Ashing uniformity

Etched uniformity after dual step oxygen plasma ashing/descum.

4" wafer coated with UV6 DUV photoresist and ashed in a 500Watt Tergeo-plus system

Recipe	Spot 1	Spot 2	Spot 3	Spot 4	Spot 5
UV6 DUV resist 200Watt, 10sccm O2, 200mTorr	173.55	186.05	177.65	168.50	177.90

+/- 5% etch nonuniformity on the 4" wafer inside Tergeo-plus system



Batch load descum uniformity





Wafar clat	Monitor	points on v	wafer (10m	Average speed	Uniformity		
water slot	Center	Right	Тор	Left	Bottom	(nm/minute)	Uniformity
1	bare wafer						
5	139.3	137.7	144.9	138.4	132	27.69	4.66%
9	126	128.3	134.1	129.3	122.4	25.60	4.57%
13	123.6	124.9	129.2	126.8	117.4	24.88	4.74%
17	121.7	124.8	129.5	124.9	114.3	24.61	6.18%
21	120.3	123.6	128.3	124.1	111.3	24.30	6.99%
25	119.4	122.7	128	123.9	110.1	24.16	7.41%
29	119.9	122.8	128.8	123.8	110.5	24.23	7.55%
33	120.8	123.8	129.9	124.6	111.9	24.44	7.36%
37	122.8	125.8	131.6	126	114.7	24.84	6.80%
41	125.4	131.4	133.7	125.1	120.5	25.44	5.19%
45	128.5	129.8	137	129.6	123.2	25.92	5.32%
49	133	135.5	144.8	135	130.3	27.14	5.34%
50			bare wafer				

Comments:

- Recipe condition: 300Watt, 140sccm, 1.06Torr pressure, duration 5 minutes. Distance between wafers: 10mm. Total 12 AZ4110 photoresist coated 4" wafers in each batch.
- Thickness at four edge points (10mm edge exclusion) and center are measured
- > The uniformity within the wafer is quite good. It's usually below 8%.
- > The uniformity of all the five points on all the wafers is 13.8%.

Courtesy of MACOM for providing the samples

Customer feedback

- 1. Claus Birger Sørensen, Center for Quantum Devices at Niels Bohr Institute, The University of Copenhagen, Denmark, For PMMA photoresist descum. "Please find enclosed the measured data in Excel. We are very pleased with the results." "so far the rates are very impressive and almost identical (3)" (03/19/2021)
- 2. Repeated purchase from an industrial customer for photoresist descum/ashing."We have been using the system and getting good results with it. We plan to purchase 2 of the same O2 plasma ashers to our Nanjing, China facility." Note: This company used our Tergeo plasma system for photoresist ashing and descum applications. After getting good results in their R&D department. They now start to purchase our Tergeo plasma systems for their production facility in China.
- 3. Repeated purchase from an advanced research team at Google in California. "We are considering purchasing one more Tergeo plus, the same system we purchased." Note: Google California had purchased five plasma systems from us. (10/14/2021).
- 4. Dr. Sara Dale at University of Bath at United Kingdoms. "Yes I'm very pleased with my Tergeo plasma cleaner, we use it mainly for cleaning off photoresist from our samples and also for cleaning bond pads for wire bonding" (10/27/2022)