IIoT and Remote O&M in the Semiconductor Industry

Webinar July 19, 2017

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Markets

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IIoT Market Coverage from Components to Cloud Systems

The following "market" slides provide the following

- The total IIoT and Remote O&M forecast (details are provided in the IIoT & Remote O&M program)
- Forecasts for the elements of IIoT systems . These elements need to be analyzed in order to best predict the market for IIoT, combust, flow and treat in the semiconductor industry
  - Cleanroom revenues, space additions, and employees
  - Cleanroom components from HVAC to filters
  - All the ultrapure water components
  - Air pollution control including scrubbers
  - Pumps and Valves
  - Wastewater treatment and reclamation (McIlvaine has reports on treatment chemicals, sedimentation and centrifugation, liquid filtration, and cross flow membranes.
  - Process filtration (Mcilvaine covers RO/UF/MF and Cartridge Filtration)
  - A big potential for IIoT is remote monitoring and control and gas of chemical delivery systems to the many tools in a semiconductor foundry. Special valves and precise instrumentation is needed. Consider that there may be 1000 tools in a facility the benefits of cloud based control are substantial.

Details on the various market reports are found at www.mcilvainecompany.com

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IIoT Purchases by Electronics Companies $ billions

World Region	2016	2018	2020	2022	2024	2026	2028	2030
Total	9	12	15	19	24	33	44	56
Africa	0.15	0.19	0.24	0.31	0.39	0.53	0.71	0.90
CIS	0.22	0.29	0.36	0.46	0.58	0.80	1.06	1.35
East Asia	5.66	7.55	9.44	11.95	15.10	20.76	27.68	35.23
Eastern Europe	0.15	0.19	0.24	0.31	0.39	0.53	0.71	0.90
Middle East	0.07	0.10	0.12	0.15	0.19	0.27	0.35	0.45
NAFTA	1.74	2.32	2.90	3.68	4.65	6.39	8.52	10.84
South & Central America	0.15	0.19	0.24	0.31	0.39	0.53	0.71	0.90
West Asia	0.15	0.19	0.24	0.31	0.39	0.53	0.71	0.90
Western Europe	0.73	0.97	1.21	1.53	1.94	2.66	3.55	4.52

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Semiconductor Room and Space Forecasts

Subject	2014	2015	2016	2017	2018	2019	2020	2021
Employees *	194.33	198.89	203.46	208.35	213.76	219.96	226.34	232.91
Room Revenues	584.47	598.19	611.95	626.63	642.93	661.57	680.76	700.50
Space Additions	1.49	1.53	1.57	1.60	1.64	1.69	1.74	1.79
Space in Use	7.78	7.96	8.14	8.34	8.55	8.80	9.06	9.32

The forecasts for employees are in thousands while the other forecasts are in millions. Room revenues are in $ while other rows are in ft2. The room revenues just include the walls, ceilings, floors, and HVAC. Mini environments and benches are included in the hardware section of the Mcilvaine *Cleanroom Report*. Ultrapure water expenditures are included in the Mcilvaine *Ultrapure Water Report.*

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Semiconductor Cleanroom Components $ millions

Subject	2014	2015	2016	2017	2018	2019	2020	2021
Total	4,285.21	4,493.12	4,713.97	4,949.78	5,201.78	5,471.63	5,758.68	6,064.06
Devices	743.94	779.78	817.84	858.49	901.96	948.54	998.08	1,050.80
Engineering & Design	442.22	463.78	486.67	511.11	537.22	565.17	594.90	626.52
Floors	313.89	329.14	345.35	362.66	381.14	400.90	421.93	444.29
HVAC	1,563.82	1,640.22	1,721.38	1,808.05	1,900.68	1,999.91	2,105.47	2,217.80
Monitoring	284.72	298.57	313.26	328.92	345.66	363.61	382.67	402.92
New & Prefilters	285.34	299.27	314.07	329.87	346.75	364.83	384.06	404.51
Replacement Filters	366.70	383.92	402.23	421.79	442.68	465.02	488.80	514.12
Walls	284.58	298.44	313.17	328.90	345.69	363.65	382.76	403.10

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Scrubber Purchases $ millions (electronics)

Subject	2014	2015	2016	2017	2018	2019	2020	2021
Total	141.09	144.40	147.72	151.26	155.20	159.70	164.33	169.10
Absorber	82.89	84.84	86.79	88.88	91.19	93.83	96.55	99.35
Adsorber	27.63	28.27	28.92	29.62	30.39	31.27	32.18	33.11
Biofilter	7.47	7.65	7.83	8.01	8.22	8.46	8.71	8.96
Dry Scrubber	9.27	9.49	9.71	9.94	10.20	10.49	10.80	11.11
Other	2.77	2.83	2.90	2.97	3.04	3.13	3.22	3.32
Particulate	11.06	11.32	11.58	11.85	12.16	12.51	12.88	13.25

Thermal oxidizer forecasts appear in the McIlvaine *Thermal/Catalytic World Air Pollution Markets*

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Ultrapure Water Purchases $1000s – All Industries

Subject	2014	2015	2016	2017	2018	2019	2020	2021
Condensate Polishing Systems	444,336.10	403,087.60	442,218.10	448,964.99	474,313.44	427,347.40	449,922.29	520,371.49
Construction	417,126.84	421,184.75	443,875.35	460,388.87	481,787.99	488,872.77	511,189.10	545,853.18
Degasification	121,256.74	119,275.96	127,058.97	131,126.12	137,738.22	136,173.73	142,825.58	155,461.68
Disinfection	70,543.07	73,350.23	76,299.51	79,457.47	82,727.11	86,308.33	89,498.63	93,322.93
Distillation	40,838.01	43,207.27	45,752.62	48,485.37	51,418.06	54,565.47	57,508.31	61,110.13
Engineering	247,906.78	250,820.09	264,118.38	274,039.60	286,704.67	291,490.66	304,727.18	324,915.59
Filtration	281,925.49	289,334.73	301,620.24	312,776.52	325,360.53	334,332.17	346,396.07	362,847.70
Heaters	81,394.74	83,978.44	86,610.15	89,406.53	92,111.49	95,154.20	97,915.23	100,782.10
IE Systems	147,095.74	149,681.84	156,645.24	162,445.74	169,548.04	173,647.75	181,484.60	192,237.25
Instruments & Controls	449,147.84	456,343.82	479,272.48	497,297.96	519,331.96	529,738.52	551,896.64	585,373.96
Pumps & Valves	239,095.85	244,743.99	255,911.25	265,611.61	276,770.11	284,089.68	294,939.55	310,391.46
RO Systems	320,791.24	322,055.25	339,794.70	351,815.67	367,915.60	370,899.65	386,961.90	414,016.99
Storage & Piping	189,569.57	192,362.41	202,430.87	210,197.53	219,909.65	224,253.79	234,446.12	249,578.50

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Ultrapure Water Purchases $1000s

Industry	2014	2015	2016	2017	2018	2019	2020	2021
Coal-Fired Power	1,108,491.43	999,279.85	1,096,700.40	1,105,938.91	1,174,336.67	1,056,806.80	1,114,522.64	1,292,776.43
Electronics	1,304,229.74	1,343,485.35	1,383,004.35	1,424,932.02	1,465,746.26	1,512,121.41	1,554,083.89	1,597,385.18
Flat Panel	648,048.37	693,411.76	741,950.58	793,887.12	849,459.22	908,921.37	972,545.86	1,040,624.07
Gas Turbines	73,923.65	79,880.51	83,550.36	92,868.64	91,145.10	91,177.35	92,403.27	95,152.62
Industrial Power	362,449.32	374,966.85	388,778.27	403,876.45	420,221.26	437,906.99	456,963.72	477,497.46
Other Industries	198,198.73	204,773.61	211,845.67	219,492.68	227,703.06	236,492.97	245,886.20	255,901.42
Pharmaceutical	433,059.28	446,332.64	460,886.30	476,778.78	494,080.09	512,916.53	518,682.01	540,204.45

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Pump Forecasts $ millions (electronics)

Subject	2014	2015	2016	2017	2018	2019	2020	2021
Total	124.45	127.37	130.30	133.43	136.90	140.87	144.95	149.16
Centrifugal	62.21	63.67	65.13	66.70	68.43	70.42	72.46	74.56
Diaphragm	20.53	21.01	21.49	22.01	22.58	23.24	23.91	24.61
Reciprocating	16.79	17.19	17.58	18.00	18.47	19.01	19.56	20.13
Rotary	24.92	25.50	26.09	26.71	27.41	28.20	29.02	29.86

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Valve Revenues $ millions (electronics)

Subject	2014	2015	2016	2017	2018	2019	2020	2021
Total	445.51	460.89	476.51	493.04	508.05	525.04	539.17	553.77
Ball	55.05	56.95	58.88	60.92	62.78	64.88	66.62	68.43
Butterfly	39.13	40.48	41.85	43.30	44.62	46.12	47.36	48.64
Check	7.83	8.10	8.37	8.66	8.92	9.22	9.47	9.73
Gate	83.84	86.74	89.68	92.79	95.61	98.81	101.47	104.22
Globe	92.05	95.23	98.46	101.88	104.98	108.49	111.41	114.42
Industrial Plug	26.14	27.04	27.96	28.93	29.81	30.81	31.64	32.49
Other	136.20	140.90	145.68	150.73	155.32	160.51	164.83	169.29
Safety Relief	5.27	5.45	5.64	5.83	6.01	6.21	6.38	6.55

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Largest Semiconductor IIoT Purchasers

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Semiconductor Supplier Market Shares

2016 Rank	2015 Rank	Vendor	2016 Revenue	2016 Market Share (%)	2015 Revenue	2015-2016 Growth (%)
1	1	Intel	53,996	15.9	51,690	4.5
2	2	Samsung Electronics	40,143	11.8	37,852	6.1
3	4	Qualcomm	15,351	4.5	16,079	-4.5
4	3	SK hynix	14,267	4.2	16,374	-12.9
5	16	Broadcom Ltd. (formerly Avago)	13,149	3.9	5,216	152.1
6	5	Micron Technology	12,585	3.7	13,816	-8.9
7	6	Texas Instruments	11,776	3.5	11,533	2.1
8	7	Toshiba	10,051	3.0	9,162	9.7
9	12	NXP	9,170	2.7	6,543	40.1
10	11	MediaTek	8,697	2.6	6,704	29.7
		Others	**150,499**	**44.2**	**159,799**	**-5.8**
		Total	**339,684**	**100**	**334,768**	**1.5**

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IIoT purchases are a function of chip production and not chip sales.

TSMC and Global Foundries are major purchasers of IIoT but do not show up in the rankings on the previous slide because they just produce the chips. Since McIlvaine is tracking cleanroom space, employees, ultrapure water investment etc. It is in a good positon to accurately rank the semiconductor companies based on IIoT purchase potential.

1Q15 Top 20 Semiconductor Sales Leaders ($M, Including Foundries)

1Q15 Rank	2014 Rank	Company	Headquarters	2014 Tot Semi	1Q14 Tot Semi	1Q15 Tot Semi	1Q15/1Q14 % Change
1	1	Intel	U.S.	51,400	11,666	11,632	0%
2	2	Samsung	South Korea	37,810	8,797	9,336	6%
3	3	TSMC*	Taiwan	24,976	4,852	6,995	44%
4	4	Qualcomm**	U.S.	19,291	4,243	4,434	5%
5	6	SK Hynix	South Korea	16,286	3,507	4,380	25%
6	5	Micron	U.S.	16,720	4,017	4,070	1%
7	7	TI	U.S.	12,167	2,791	2,939	5%
8	8	Toshiba	Japan	11,040	2,793	2,750	-2%
9	9	Broadcom**	U.S.	8,428	1,984	2,058	4%
10	12	MediaTek**	Taiwan	7,032	1,608	1,799	12%
11	10	ST	Europe	7,384	1,820	1,700	-7%
12	13	Infineon	Europe	5,938	1,440	1,672	16%
13	15	Avago**	Singapore	5,644	1,305	1,615	24%
14	11	Renesas	Japan	7,307	1,865	1,470	-21%
15	14	NXP	Europe	5,647	1,246	1,467	18%
16	17	Sony	Japan	5,292	1,011	1,272	26%
17	20	GlobalFoundries*	U.S.	4,355	980	1,190	21%
18	18	Freescale	U.S.	4,548	1,093	1,169	7%
19	23	Sharp	Japan	3,515	700	1,137	62%
20	21	UMC*	Taiwan	4,350	1,006	1,133	13%
—	—	Top 20 Total	—	259,130	58,724	64,218	9%

*Foundry **Fabless ***6% growth excluding the foundries

Source: Company reports, IC Insights' *Strategic Reviews* database

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TSMC is Largest Chip Manufacturer

- Established in 1987 and headquartered in Hsinchu Science Park, Taiwan, TSMC pioneered the pure-play foundry business model by focusing solely on manufacturing customers' designs. The Company does not design, manufacture or market semiconductor products under its own brand name, ensuring that it does not compete directly with its customers.
- Today, TSMC is the world's largest semiconductor foundry, with owned capacity expected to reach more than 11 million 12-inch equivalent wafers in 2017. With such a large and diverse global customer base, TSMC-manufactured semiconductors are used in a wide variety of applications covering various segments of the computer, communications, consumer, industrial and standard semiconductor markets. Such strong diversification helps to smooth fluctuations in market demand, which, in turn, leads to higher levels of capacity utilization and profitability.
- Annual capacity of the manufacturing facilities managed by TSMC and its subsidiaries reached above 10 million 12-inch equivalent wafers in 2016. These facilities include three 12-inch wafer GIGAFAB® facilities, four 8-inch wafer fabs, and one 6-inch wafer fab in Taiwan, as well as two 8-inch wafer fabs at wholly owned subsidiaries: WaferTech in the United States and TSMC China Company Limited.
- In March 2016, TSMC and the municipal government of Nanjing, China signed an investment agreement affirming that TSMC will make an investment to establish TSMC Nanjing Company Limited, a wholly-owned subsidiary managing a 12-inch wafer fab and a design service center. Planned capacity is 20,000 12-inch wafers per month. The facility is scheduled to commence production of 16nm process technology in the second half of 2018. The purpose is to provide closer support to customers as well as expand TSMC's market share and business opportunities in China in step with the rapid growth of the Chinese semiconductor market over the last several years. TSMC provides customer service through its account management and engineering services offices in North America, Europe, Japan, China, South Korea and India. The Company employed about 47,000 people at the end of 2016.
- *In the mid 1980s at Semi-Con West Bob McIlvaine as cleanroom news editor was invited to interview a Morris Chang who was pursuing the strange idea of manufacturing chips for devices made by other companies.*

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TSMC has 56% Foundry Market Share

- TSMC estimates that the worldwide semiconductor market in 2016 was US$357 billion in revenue, representing 1% year-over-year growth, continuing the flattish growth in 2015. In the foundry sub-segment of the semiconductor industry, total revenue was US$47 billion in 2016, representing 8% YoY growth, accelerating from 4% in 2015 due to a healthier market and inventory replenishment.
- TSMC maintained its leadership of the total foundry segment of the global semiconductor industry in 2016 with an estimated market share of 56%. Advanced technologies continued to be a key factor in TSMC's strong market position and 54% of TSMC's wafer revenue came from manufacturing processes with geometries of 28nm and below in 2016.
- TSMC forecasts the total semiconductor market to grow 4% in 2017. Over the longer term, driven by increasing semiconductor content in electronic devices, continuing market share gains by fabless companies, gradual increase of IDM outsourcing, and expanding in-house Application-Specific Integrated Circuits (ASIC) from system companies, the Company expects foundry segment revenue growth to be much stronger than the 3% compound annual growth rate projected for the total semiconductor industry from 2015 through 2020.

TSMC Water and Energy Improvements

- TSMC has set long-term targets for water conservation, waste recycling, energy saving, and greenhouse gas emissions to minimize our environmental impact, and has made clear progress in reaching these goals.
- In water conservation, TSMC set a goal of reducing water consumption per 8-inch equivalent layer to 30% below 2010 levels by 2020. As of 2016, it achieved 47.7 liters per 8-inch equivalent layer versus 62.6 liters in 2010, a 23.8% reduction.
- In waste reduction, the goal was to reach a waste recycling rate of 95% by 2020. TSMC reached this target in 2015 and continued to maintain a 95% recycling rate in 2016.
- In energy conservation, the goal is to reduce power consumption per 8-inch equivalent layer to 12% below 2010 levels by 2020, or 9.33 kilowatt hours. As of 2016, TSMC reached 9.7 kilowatt hours, versus 10.6 in 2010, for an 8.5% reduction.
- In greenhouse gas emissions, the goal is to reduce emissions per per 8-inch equivalent layer to 18% below 2010 levels by 2020, and TSMC achieved a 10% reduction in 2016.

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TSMC Water Treatment

- TSMC's ultra-pure water system turns raw water into ultra-pure water mainly used in process tools for cleaning chemical residue on wafer surfaces. To reduce total water usage, TSMC's effluent water from ultra-pure water systems and process tools are graded by purity.
- The cleanest is reused by in the manufacturing process.
- The second grade taken from the recycling treatment is employed in secondary uses such as cooling tower water.
- Wastewater that cannot be recycled is discharged to treatment facilities for final wastewater treatment. TSMC adopts a strict front-end wastewater categorization strategy to improve treatment efficiency.
- Wafer fabs' wastewater can be divided into fluoride, general acid, and various polishing wastewaters. All kinds of wastewater are strictly categorized at process tools, and collected to wastewater treatment facilities through separated piping, carefully operated and maintained by professional teams to comply with the standards of the Science Park Administration (SPA). The water is then discharged to the SPA wastewater treatment plant for further treatment after professional teams ensure the discharge complies with SPA standards.
- The treated wastewater is discharged to rivers from the SPA's wastewater treatment plants in compliance with river discharge standards.

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TSMC Wastewater Treatment

Each fab is equipped with effective wastewater treatment systems including complete backup systems, such as emergency power supplies, to reduce the likelihood of abnormal discharge.

Operating status of all of TSMC wastewater treatment systems are monitored 24 hours a day by shift personnel. If operating conditions shift from the preset limits, a warning signal is sent and wastewater discharge is halted. Data gathered for monitoring system effectiveness have been designated an important tracking item to ensure the effluent's quality.

Wastewater Effluent Monitoring Results - All TSMC fabs are equipped with continuous monitoring equipment to monitor and record changes in water quality, such as acidity and fluoride ion concentration, and quantity in order to take appropriate responses when abnormal situations occur.

TSMC also conducts off-site sampling and analyzes wastewater effluents' quality at least four times a year, which also provides a calibration reference for on-line analyzers, ensuring that TSMC complies with water quality standards

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TSMC Air Pollution Control

- TSMC installs local scrubbers behind process tools in order to optimize waste gases treatment efficiency. First, high temperatures or other physical and chemical measures are used to significantly reduce the concentration of pollutants in tool exhaust. The gas is then inducted to central waste gas treatment equipment for end-point treatment. End point treatment includes zeolite-rotary-wheel absorbing equipment for volatile organic chemicals (VOC) treatment and wet scrubber equipment for acid or base gases. All equipment can minimize pollutant concentrations to ensure complete compliance with environmental regulations.
- TSMC has installed effective air pollution control equipment, including backup systems, for all pollution control equipment to continue waste gas control in the event of equipment breakdown and lower the risk of air pollutant emission. To ensure normal equipment operations, TSMC has installed backup fuel supply systems for VOC pollution control equipment that will engage if the original fuel supply system experiences difficulties. Operational status of all of TSMC air pollution control systems is monitored 24 hours a day by shift personnel. Data collected by system efficiency monitoring have been classified as an important tracking item in order to ensure air exhaust quality.
- All TSMC fabs continuously monitor the real-time concentration of VOCs and conduct annual emission measurements as required by environmental laws. Emissions have been far below EPA standards every year.

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TSMC Facilities

TSMC operates

- three advanced 12-inch wafer GIGAFAB™ facilities (fab 12, 14 and 15),
- four eight-inch wafer fabs (fab 3, 5, 6, and 8), and
- one six-inch wafer fab (fab 2).
- TSMC also manages two eight-inch fabs at wholly owned subsidiaries: WaferTech in the United States and TSMC China Company Limited, and its joint venture fab; SSMC in Singapore.

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TSMC Projects have been Reported in McIlvaine Publications since 1987

TSMC building Fab 15 with capacity of 100,000 12 in wafers/month

2010-- Chip manufacturer Taiwan Semiconductor Manufacturing Co (TSMC) is building its third 12in Gigafab in Taichung's Central Taiwan Science Park.

Fab 15 will be TSMC's third Gigafab (fab with a capacity of more than 100,000 12in wafers per month) and the firm's second Gigafab to be equipped for 28nm technology.

Construction on a site of 18.4 hectares will be in four phases, and total investment is expected to exceed NT$300bn (US$9.4bn).

The fab will have building area of 430,000m^2 and a cleanroom area of approximately 14 football pitches (104,000m^2).

TSMC says it will begin moving in equipment for the Phase 1 facility in June 2011, with volume manufacturing of 40nm and 28nm products starting in the first quarter of 2012. More advanced process nodes will be introduced as TSMC's technology development continues to advance.

TSMC will also continue to expand capacity at its Fab 12 in Hsinchu and Fab 14 in Tainan. The combined capacity of Fab 12 and Fab 14 currently exceeds 200,000 12in wafers per month. This will exceed 240,000 12in wafers per month by the end of 2011.

In common with Fab 12 and Fab 14, Fab 15 will 'green' and incorporate environmentally friendly concepts in energy conservation and pollution control, including a process water conservation rate of 85%, reclamation of rainwater, recirculation and reuse of general exhaust heat, and development of solar power generation and LED lighting applications. TSMC says its goal is to reach zero emissions of greenhouse gases.

Fifth phase of TSMC Fab 14 construction started

2012-Chip manufacturer Taiwan Semiconductor Manufacturing Co (TSMC) has held a groundbreaking ceremony for the fifth phase of its Fab 14 gigafab at the South Taiwan Science Park in Tainan, Taiwan.

The new facility will be TSMC's second 20nm fab area, scheduled to begin volume production in early 2014.

TSMC's Phase 6 at Fab 12 in Hsinchu, coming on stream next year, will be the first fab area to manufacture on 20nm for TSMC. The Fab 14 Phase 5 facility will be combined with the planned Phase 6 to offer a total cleanroom area of 87,000m^2, the equivalent of more than 11 football pitches and four times larger than a typical 12in fab, TSMC said.

Fab 14 is TSMC's second 12in fab following Fab 12. Phase 1 began volume production in 2004. With Phases 1–4 now in operation with an estimated value of US$6bn, Fab 14 has a capacity of 500,000 12in wafers each quarter.

The firm expects the combined annual revenue of Phases 5 and 6 to reach a similar scale.

Around 4,600 people are currently employed at Fab 14 and the expansion will create another 4,500 jobs, the semiconductor firm said.

TSMC is Moving to 5nm Production by 2020

- To meet customer's needs in today's dynamic and fast-changing marketplace, TSMC is accelerating the pace of its innovation by offering leading-edge processes to suit their power and performance requirements. Many of technological breakthroughs in materials, processing, and advanced lithography are not only enabling devices to be faster, smaller and more power efficient
- The 10nm process was transferred from R&D to operations for volume production in fourth quarter of 2016, with a fast production ramp

  scheduled for the second half of 2017. Yield has been faster than previous nodes including 20nm and 16nm.
- TSMC's 7nm development was focused on manufacturing baseline process setup, yield learning, reliability evaluation, and transistor and interconnect R/C performance improvement in 2016. During the year, major customers and IP vendors completed IP design and started silicon validation. The 7nm process entered risk production in the first half of 2017 with volume production scheduled for 2018.
- Development activities for 5nm in 2016 focused on test vehicle design and implementation, mask making, and pilot run. EUV lithography will be used to reduce complex multiple-patterning process steps and risk production is scheduled for second quarter 2019 with volume ramp in 2020.
- In 2016, the EUV lithography program improved light-source power and stability, enabling faster learning rate and process development for advanced nodes. Additional progress was made with resist process, pellicle, and related mask blanks, as EUV technology moves closer to full scale R&D and manufacturing readiness.
- Integrated Fan-Out Package on Package (InFO-PoP) technology integrating 16nm SoC and DRAM for advanced mobile products began volume production in the second quarter of 2016. It enables a thinner package, 10% less thermal resistance, more logic I/Os, and 5 to 10% higher maximum operating frequency for application processors.

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The Semiconductor IIoT Challenge

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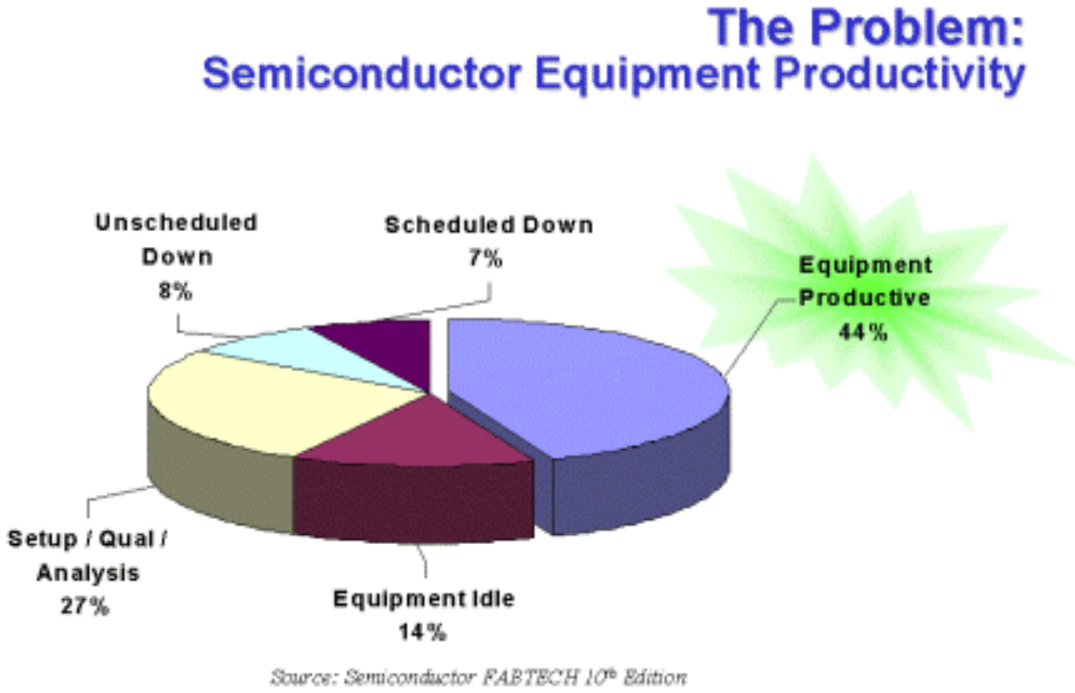
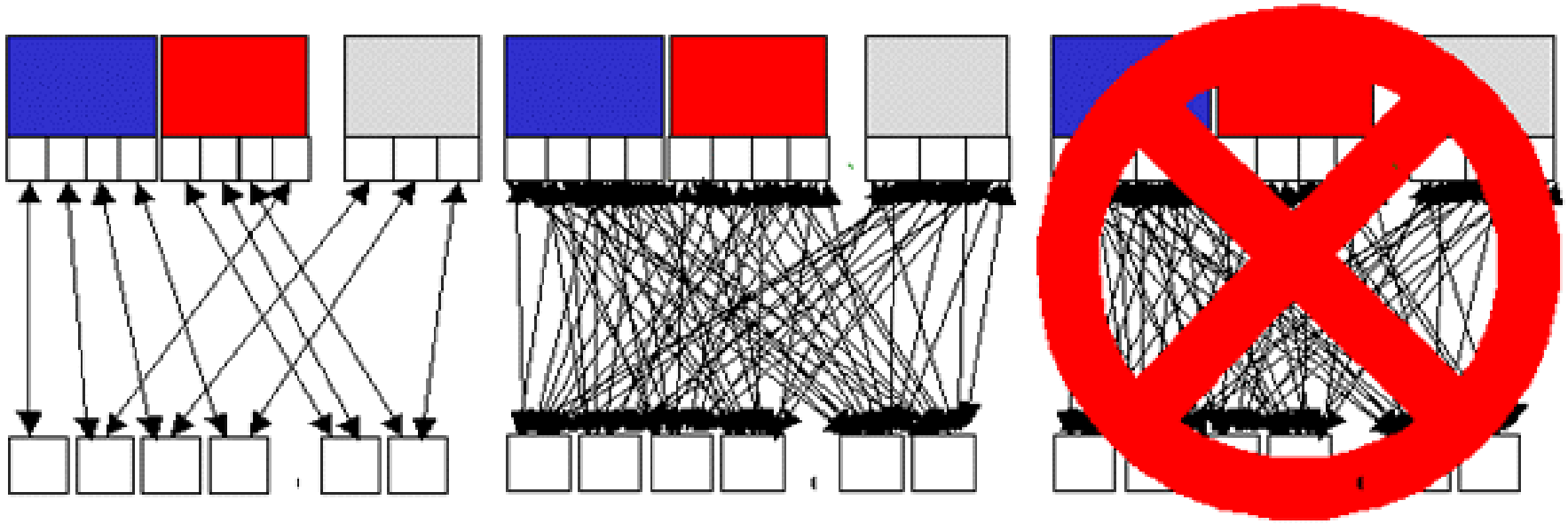
Remote Monitoring and Quick Response to Improve Semiconductor Equipment Productivity

The unscheduled breakdown of an individual piece of manufacturing equipment is a great cost burden, as it results in downtime for dependent/related equipment in the manufacturing chain. Inefficiencies of a single piece of critical "bottleneck" process equipment can have a negative economic impact for an entire production line. Since numerous competitive equipment manufacturers supply the various discrete tools needed in a single fab, service, tool monitoring, and data collection for the tools are inefficient and cumbersome processes Semiconductor industry statistics show that most semiconductor capital equipment suffers at least 8% unscheduled downtime and loses another 7% to scheduled maintenance. At the January 2000 ISS, Michael Splinter, Senior Vice President and General Manager of Intel's technology and manufacturing group, estimated that each hour of downtime for a critical unit of process equipment can translate into $100,000 of lost revenue in today's chip-hungry market. In a typical fab, just reducing downtime by 1% on the 50 most critical tools can provide revenue opportunities and cost savings nearing one hundred million dollars annually.
One way to reduce unscheduled downtime is to improve response time and repair time, and, eventually, to predict when problems will occur before they occur.



The Challenge of Monitoring Multiple Supplier Systems and Multiple Fabs

The following diagram shows a progression from a few point-to-point connections to a full scale implementation where multiple suppliers are providing connections to multiple factories.



Single point-to-point connections can be supported when a small number of suppliers and customers are engaged, however as the network grows this approach quickly becomes unmanageable.

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Critical issues in gas delivery for advanced semiconductor processing

By Hubert Dinh, Mohamed Saleem, Ph.D. and Sowmya Krishnan, Ph.D., Ultra Clean Technology

Repeatable gas delivery to process chambers is of paramount importance to advanced semiconductor processing. It is equally important to eliminate any potential problems with these systems, such as corrosion in the wetted areas of gas delivery components. As semiconductor processing enters extreme, deep submicron regimes, the requirement for precision gas delivery combined with good repeatability and reliability becomes even more critical, especially for a variety of processes such as etch, atomic layer deposition (ALD) and chemical vapor deposition (CVD). Many gas delivery components, such as mass flow controllers (MFCs), and pneumatic and ALD valves, are pushed to their limits for device geometries extending below 60 nm. It is essential to understand and predict the state of these components prior to running process recipes in the processing tool.

The repeatability of specialty gas flow to the process chamber can be dictated by the health of these critical components. For example, a reaction between halogen gases and residual moisture when present in the gas delivery system can trigger an onset of corrosion in the sensor tubes of the mass flow controllers, which if not monitored can lead to catastrophic failures. Similarly, any failures of the high-speed ALD valves (including corrosion/contamination and failure of the valve diaphragms and seats) can affect the dosage of the expensive ALD precursors leading to erroneous process results.

Manufacturers have designed valves with special diaphragms and seat materials with life cycles greater than 25 million cycles.[2] However, all of the life cycle data is based on operation in inert gases such as nitrogen. Many of the precursors used in ALD processes, on the other hand, are highly reactive and require high temperatures to maintain vapor phase. It is not known how these valves will perform under these specific process conditions. As ALD processes become mainstream, and more and more new precursors are identified that would impart specific properties to the gate dielectric, understanding the reliability of the components used for pulsing the precursors will become critical.

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Integrated Fab Data Systems Track Health of Gas Delivery Systems

- Since the inception of e-diagnostics in early 2000, multiple teams within the semiconductor industry, including chip makers and OEMs alike, have been actively engaged in e-diagnostic activities to support the industrywide implementation of advanced process control (APC), and fault detection and classification (FDC) techniques. APC refers to passive and active processes, and wafer data mining and tool-to-tool process adjustments. FDC is a technique focused on detecting real-time tool and process deviations and isolating the root cause.[3] The implementation of these techniques has historically faced several challenges such as the lack of a consensus strategy for integration of various systems from different suppliers. This leads either to poor-quality parametric data transfer or to unavailability of critical data when requested.
- Today, with the availability of more and more in-situ metrology capabilities and FDC on their tools, OEMs have begun to integrate the resultant data streams into a centralized fab data system. However, large amounts of this sensor and tool data are either unsynchronized or not applicable for use in APC protocols.[5]Even though there are rich pools of sensor and tool data available, maintenance alerts are still most often provided only after a failure has occurred. The time spent on trial-and-error design of experiments isolating the root cause may take weeks, forcing extended tool downtime, the cost of which can typically be in excess of $100,000 per hour.[6] It is, therefore, imperative that any process-critical parameters deviating from specifications be detected in advance at the gas delivery system level. This will allow for the rapid implementation of corrective action.
- The techniques used in APC and FDC can be applied to monitor the state of health of a gas delivery system. This can be accomplished through the use of a graphical user interface (GUI) tool integrated with the gas panel. The GUI can be capable of monitoring the entire gas system with the touch of single key In principle, this software may also work across industry-common communication protocols via proprietary algorithms. Using such a tool, the user can quickly scan the performance of a gas panel by accessing digital information from various components. By processing the information, an assessment of the health of the components can be made for the entire gas panel. This ability to monitor, analyze and diagnose real-time transient values, gives users the opportunity to troubleshoot flow excursions prior to running processes.

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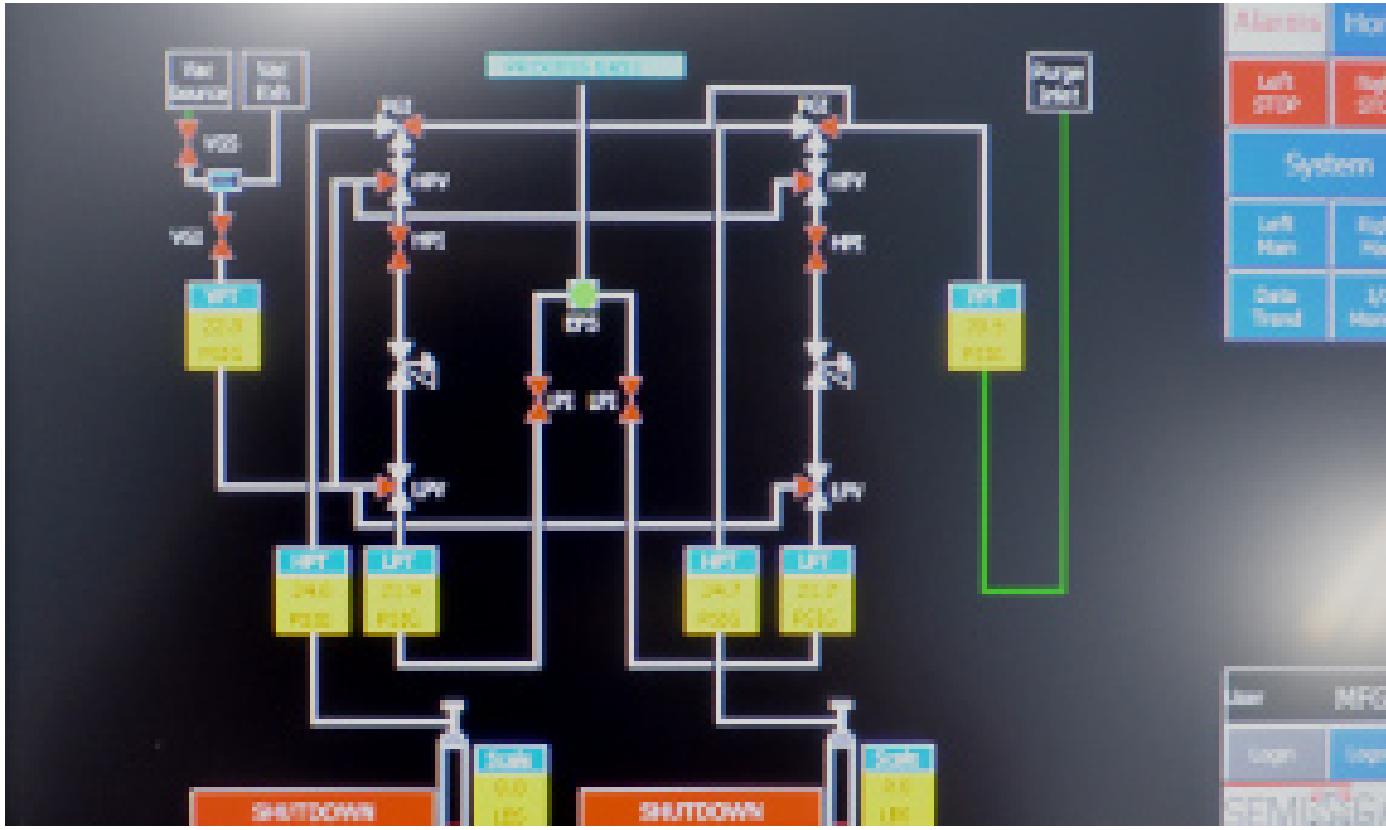
Suppliers

McILVAINE

Applied Energy Systems Gas Delivery

Since its founding in 1980, Applied Energy Systems' SEMI-GAS® brand has been serving the evolving requirements of the semiconductor industry .
Custom gas source and distribution system that combines the functionality of multiple gas cabinets and valve manifold boxes into one dynamic system.
Controls the supply of up to 10 process gases to one or multiple points of use, or tool chambers, from both internal and external source supplies, via a single user interface.
Perfectly suited for semiconductor process tool and research applications, by enabling the operator to quickly and easily switch between process gases for experimentation and recipe development.
Eliminates the need for multiple safety devices including gas, exhaust and fire detection units, as well as separate gas source and distribution system controllers.
Minimizes cost of ownership by reducing several utility requirements, such as exhaust, clean dry air, electricity and purge gas supply.



Brooks Instruments provides DLI Vaporizers as well as Mass Flow Instruments

- Many conventional vapor delivery systems have fundamental limitations that affect their applicability to highly demanding semiconductor processes. “Bubblers”, or vapor draw systems, are difficult to start and stop, require very close control of temperature and pressure, and are inefficient at generating well controlled vapor mass flow. "Flash vaporizers" that apply heat to the liquid using a hot metal surface are also inefficient at generating vapor mass and frequently can cause thermal decomposition of the liquid precursor. None of these conventional technologies can eliminate the potential for liquid carry-over and the major process contamination this engenders.
- Brooks Instrument DLI (direct liquid injection) vaporizers employ hot gas, rather than a hot metal surface, to accomplish liquid vaporization. As liquid enters the hot gas chamber, it is atomized by a carrier gas stream. Once the atomized liquid contacts the hot gas, it immediately changes to vapor. The result is chemically pure vapor, free of decomposition by-products or liquid carry-over. The result: Semiconductor deposition processes that require liquid-to-vapor creation have the purity and vapor mass flow control required for the highest levels of throughput and wafer quality.

McILVAINE

Dakota Semiconductor Gas Delivery System

Dakota works with semiconductor customers from prototype to production. Dakota's production ready facility features class 100 & 1000 clean rooms, clean assembly space, and final test bays to run complete equipment testing and validation before shipment.
They believe that all subsystems and completed process tools should be fully functional tested prior to shipping from Dakota. To achieve this Dakota has (7) cleanroom and (4) industrial test stations. Critical Systems are fabricated, assembled and tested in a Class 100 and Class 1000 clean room facilities, including:
Semi grade gas- Argon, N2, He, CDA
1 Meg cooling water
18 M-ohm DI water system
3 phase high voltage electrical supply (480V, 300A capability)
Vacuum and Cryopump Exhaust
Helium Leak Testing Standard
High Pressure Testing available
High Bay and Overhead Crane

Honeywell supplies the Automation Software, Sensors, Logic Controllers and Smoke Detection Systems for Chip Manufacturers

Honeywell supplies complete IIoT cloud based systems, sensors, and software components. The two products with proven use in the semiconductor industry are the HC900 process and logic controller and VESDA automated smoke detection systems. Details on these two products follow but raise the question how do they fit in with the larger IIoT initatives of the company.

- The Honeywell HC900 is an advanced process and logic controller based on a modular, scalable design that is sized to meet the automation needs of a wide range of HVAC equipment. The HC900 can be used for a host of diverse control tasks – from process programmable logic controllers (PLCs) to low-end distributed control system (DCS) applications. The controller's touch screen operator interface provides user-friendly pre-built or custom displays, along with trending, data archiving and a host of other capabilities.
- The HC900 is a solution to most PLCs for semiconductor industry applications. It offers a selection of controller CPU modules, multiple I/O rack sizes, and local or remote I/O racks providing a flexible architecture that can accommodate the most demanding application. Modularity, built-in redundancy, versatile I/O configuration and connectivity, plus the ability to configure complete process solutions and archive their program parameters for easy retrieval and implementation, permit customized, pinpoint control. The HC900 utilizes a secure engineering software tool that minimizes project development and commissioning time, and helps to protect intellectual property. This Windows™-based application uses graphic objects to represent function blocks, greatly simplifying control strategy development and improving configuration record keeping.

McILVAINE

Honeywell VESDA Automated Smoke Detection

Look for	Why?	What VESDA offers
The best sensitivity	To achieve the earliest possible warning of a fire	VESDA can detect smoke at 0.005% obscuration per meter
A wide sensitivity range	So that detection levels can be set to suit the environment, avoiding false alarms	VESDA detectors have a sensitivity range of 0.005%–20% obscuration/m
A redundant peer-to-peer communications network	To give you flexibility in positioning and programming detectors and display modules	The VESDAnet communication network allows you complete installation flexibility
Multiple programmable alarm thresholds	So that the response can be appropriate for the stage of the fire, from 'Investigate' at the first alarm through to 'Activate de-smoke system' or 'Release suppression' at the fourth alarm level	VESDA has 4 programmable alarm levels
Event log and reporting	A forensic tool for investigating faults, alarms, user actions and smoke trends.	Each VESDA detector has an event log that stores the last 18000 events
A wide product range	So that there's a product to suit any size area that you want to protect… from a large open manufacturing floor to within the confines of production equipment	VESDA has the widest product range on the market
Absolute calibration	Ensures repeatable and reliable detection of very slow growth incipient fires	VESDA is the only aspirating smoke detector with Absolute calibration
Monitoring of particles less than 10 microns diameter	Ensures that smouldering fires in a clean room are detected early	VESDA detectors can detect particles smaller than 0.1 microns
Monitoring and control of smoke detectors from a Central Monitoring Station or Emergency Control Room	Allows response to be controlled and monitored from a central point by trained operators	Using VESDA System Management (VSM4) software, every VESDA detector can be controlled and monitored remotely.
An accredited global distribution and support network	So you get the right technical advice when you need it	All distributors of VESDA products are factory-accredited

McILVAINE

Silica Removal for Semiconductor UPW

July 19, 2017- The presence of silica in high purity water can be particularly detrimental to the manufacture of semiconductors on the surface of a single crystal of silicon. This presentation is by Jean Holz Applications Development Manager, Power at Hach.

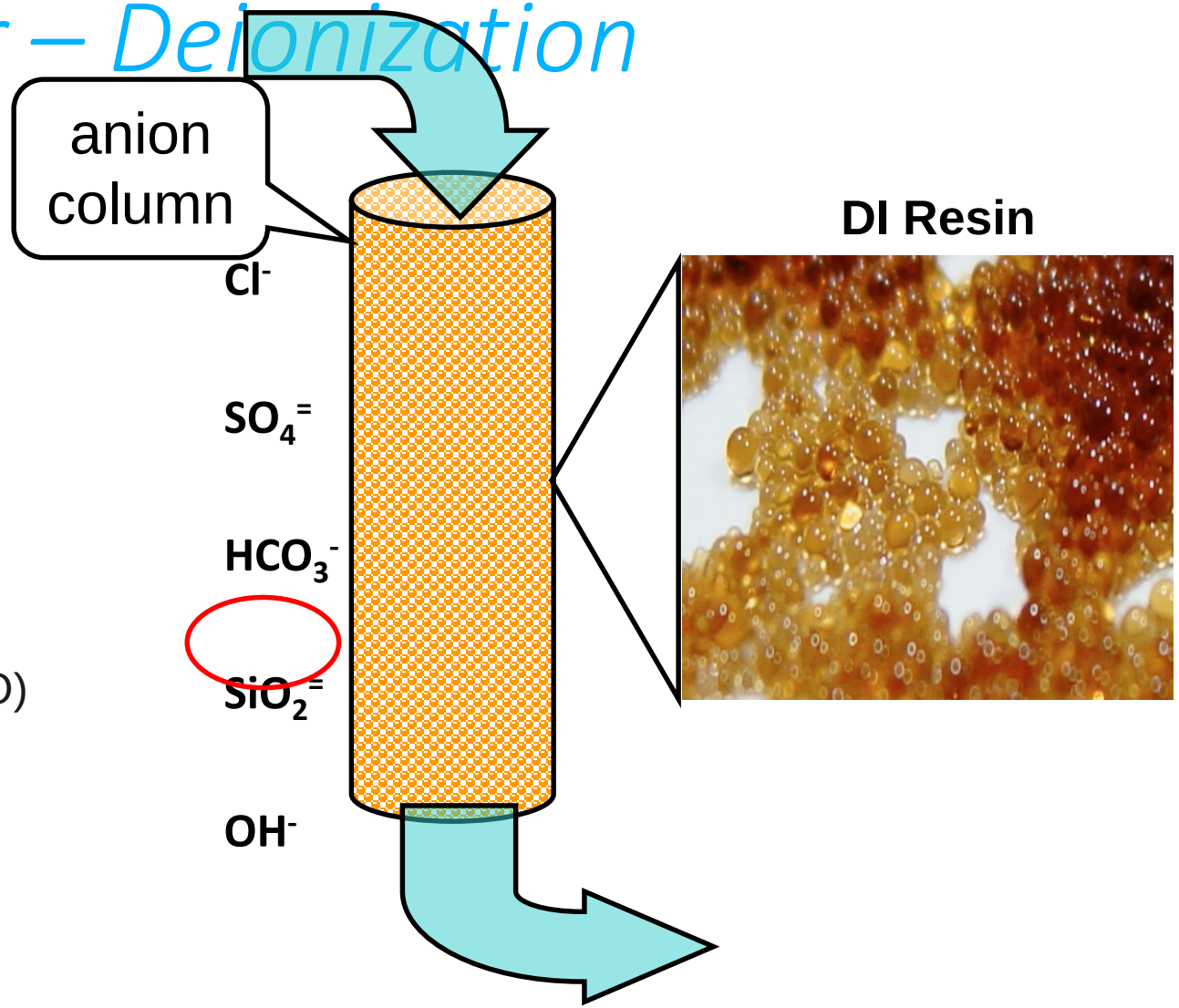
Mcilvaine believes the cross pollination between industries is very desirable. This presentation will be verification of that thesis.

McILVAINE

Incoming Water – Deionization

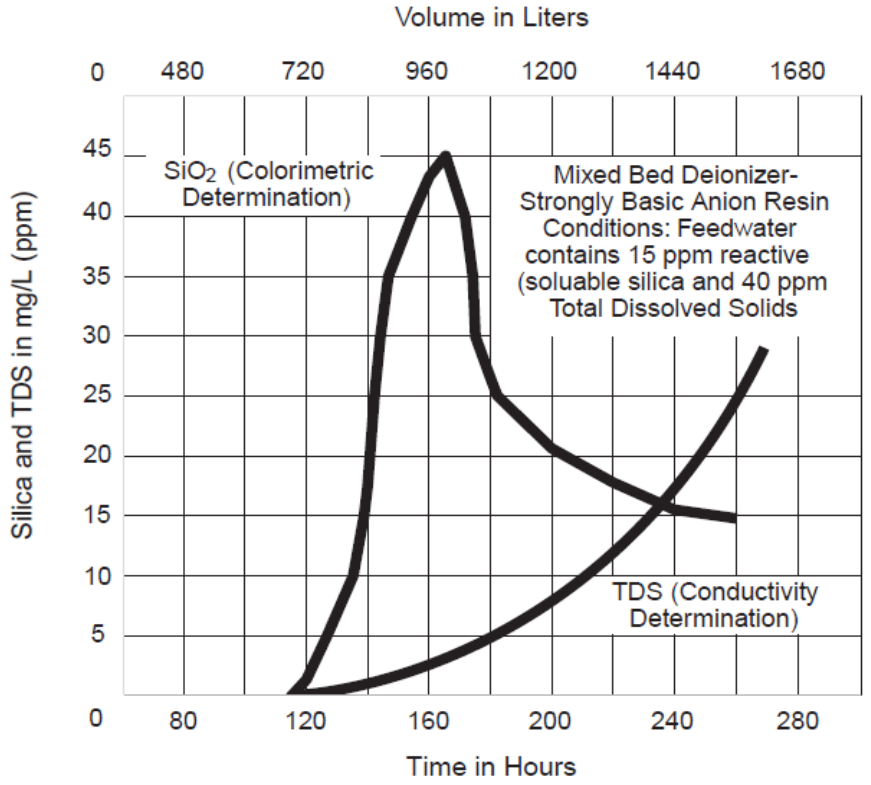
The most common methods for **removing silica** from water are:

1) lime softening
2) ion exchange
3) reverse osmosis (RO)



Water Purification – Resin Depletion

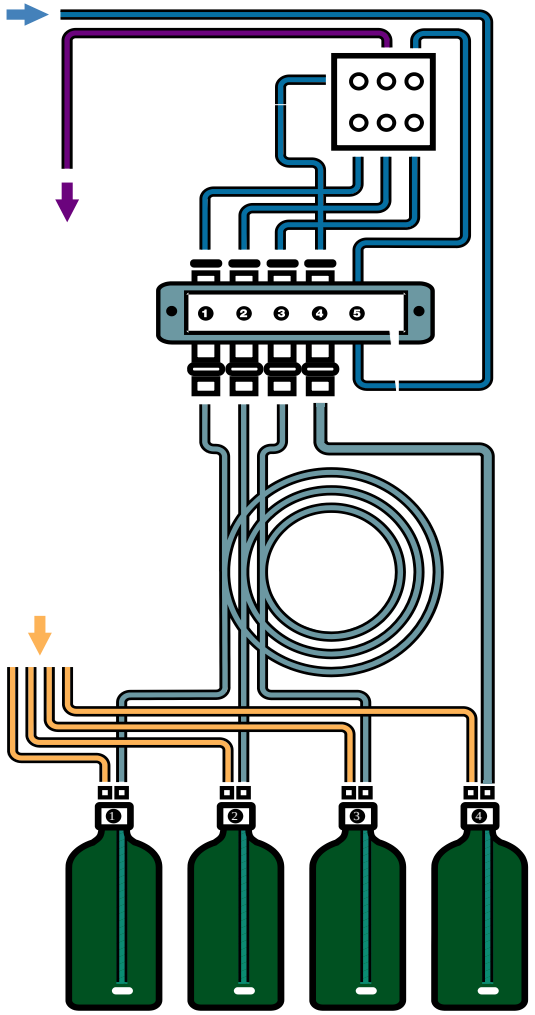
- Monitoring resin exhaustion via conductivity technologies is not best practice.
  - Silica detection much faster with specific analyzers



Specific ion vs. conductivity

Theory of Operation

- (R1) Acidic Molybdate 3 reagent solution reacts with silica and phosphate to form yellow silicomolybdic acid complexes and phosphomolybdic acid complexes.
- (R2) Citric Acid Surfactant reagent destroys the molybdophosphoric acid complexes, removing phosphate interference.
- (R3) Amino Acid F Reagent reduces the yellow silicomolybdic acid to an intense blue color, proportional to the silica concentration.
- Test results are measured at 810 nm.



Energy Efficiency Synergy

Presented by:

Les Goldsmith

ENVIRCO Brand of JCI

lgoldsmith@trioniaq.com

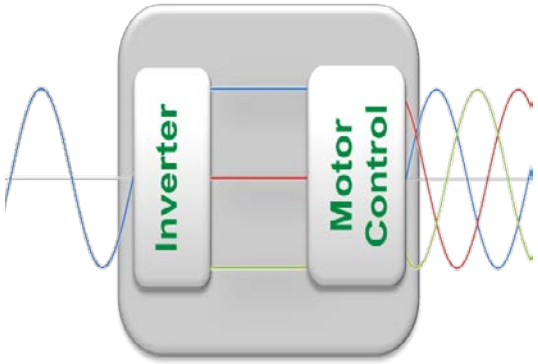
- 14 years as National Sales Manager for ENVIRCO
- Prior served 6 years at LIBERTY INDUSTRIES
- Introduced to the USP 797 over 16 years ago
- Voting member on RP 0036 for Fan Filter Units
- Have many high level contacts in clean room industry: design, construction, equipment, certification, consulting and product procurement

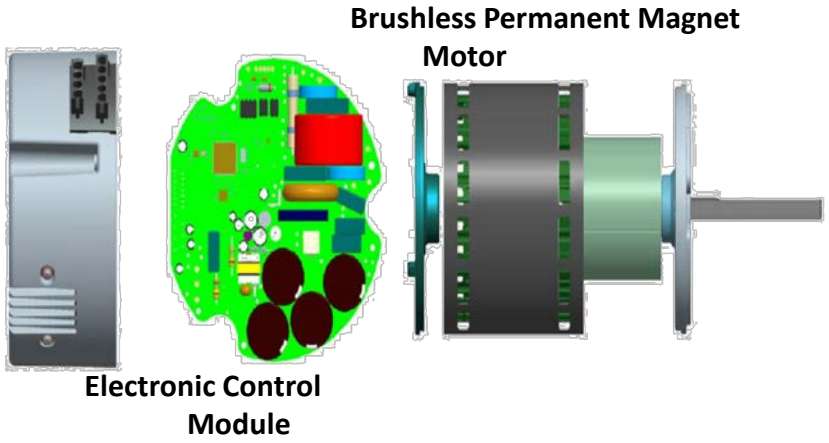
ENVIRCO
Innovators in clean air technology

New Age Motors - ECM

Electronically Commutated Motors

- Are brushless DC motors where the direction of the electric current is switched using electronics vs. brushes (also called brush-less)
- ECM advantages
  - Typically smaller units
  - 33% to 50% reduced energy consumption vs. AC Motors
  - Lower energy consumption equates to lower heat generation
  - Lower heat dissipation allows wider temp operating range
  - More reliable, 25% longer typical life, 100K hours vs. 80K hours
  - Improved control via independent variance of motor speed and torque





ECM Impediments

For existing equipment

- If it isn't broke, don't fix it
- ECMs are smaller and typically mechanically incompatible
- ECMs cost more up-front
  - Originally ECM was 4x cost of AC motor
  - Today typically a 2x differential

For new equipment or upgrades

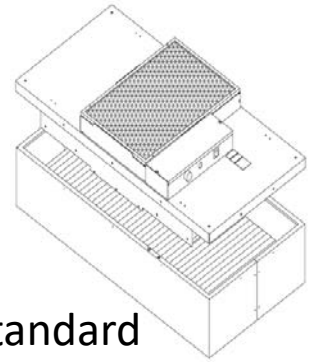
- ECMs cost more up-front
  - Originally ECM was 4x cost of AC motor
  - Today typically a 2.5x differential
- But, 92% of lifetime motor costs are operational costs ~ Electricity
- Until now building contractor budgets limited ECM deployment
- Today most equipment manufacturers typically offer both AC motors and ECM powered systems

Let’s introduce a cleanroom application to support explanation of ECM advantages

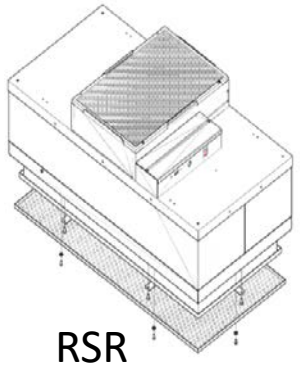
- Fan/filter units, or FFU's, in their basic configuration, are a HEPA or ULPA filter mated to a fan, or motorized impeller. The compact, low profile units are designed to fit into a standard suspended ceiling grid, in many cases on 2’ x 4’ centerlines.
- In 1984, FFU's were introduced to provide an alternative to ducted terminal filters. Ducted terminal filters didn’t have sufficient performance to serve higher static pressure requirements. Also they ducted terminal filters require extra space for ducting.
- Furthermore, combined with the negative plenum design, FFU's could be used in standard suspended ceilings without the concern of by-pass air. This approach became the "quick-fix" for a multitude of class 1,000 -100,000, small sized cleanrooms.

Styles of FFUs

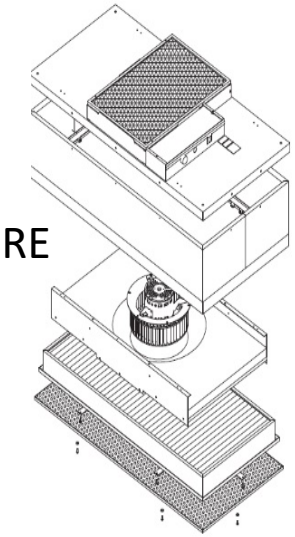
- UL or ETL fan box
- UL 900 qualified filter
- Standard Style
- RSR Style – filter roomside replaceable
- RSRE Style – filter and motor-blower room-side replaceable



Standard



RSR



RSRE

Example 2x4 FFUs

ECM

2x4 Standard LEDC

Equipped with an ECM

Equipped with an AC Motor

2x4 Standard LEAC

Pro-ECM Basic Economic Advantage

Quick example, based on a small 20 FFU based cleanroom in California: *ECMs save $832 per year*

Units	Product	Approx Price Each	Watts @90CFM	Electricity Cost kwh	Daily Use	% Cutback	Yearly Operating Cost	10 Yr Total Cost
20	LEAC 2x4 AC FFU	$1,400	170	$0.145	24	0%	$4,319	$71,187
20	LEDC 2x4 DC FFU	$2,000	90	$0.145	24	0%	$2,286	$62,864

Additional merits to consider for ECM based products

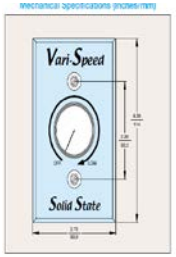
1) *ECM produces less heat*
2) *ECM improves machine performance*
3) *Plus ECM motor life is typically 2 years longer*

Saving Energy Saves $

FFU Controls, Basic to Variable to GUI Based Controllers w/Multi-Zone & Sensors

Manual On/Off

2-3 Speed Selector



Continuously Variable Speed Selector

Networked Control

Type	Variable Speed	Automatic	Networked	Merit Score Energy
Manual	No	No, manual	No	0
Manual Speed	Yes 1 of 3 speeds	No, manual	No	1
Variable Speed	Yes, wide range	No, manual	No	5
Function x1*	Wide range + time control	Yes	Yes	25
Function x2*	Multi-Zone	Yes	Adds Multi-Zone and BMS Support	50
Function x3*	Automatic	Yes	Adds Sensor Integration	100

** See next slide for controls details at this level*

High Integration Controls Examples

Function	Use Case and Value Add (Automation, Safety & Energy Efficiency)
x1	Real-Time clock automatically controls all FFUs specifically at different speed/performance levels at different times of the day and for different days of the week. Monitors the FFUs and alert/alarms if problem detected. Can interlock functions including lighting, security, etc. Does not require man-power.
x2	Multi-Zone, Provides functions 1x above but segregates and controls entire cleanroom via separated zones. Each zone can be independently controlled. Also can interlock control functions between zones. Can interlock entry, HVAC, lighting, security etc.
x3	External networking, Provides all x1 & x2 functions. Connects to BMS Building Management System and to other internet manual control points including SmartPhones, supports printing, maintenance requests, operational reporting, data logging etc. During periods of light loading time shares FFUs extending service life
x4	Super automatic system, controls itself via many sensor types all networked throughout the cleanroom. Controller monitors all sensors and automatically controls, compensates, alarms, reports

Controls Stimulus #3 Sensors

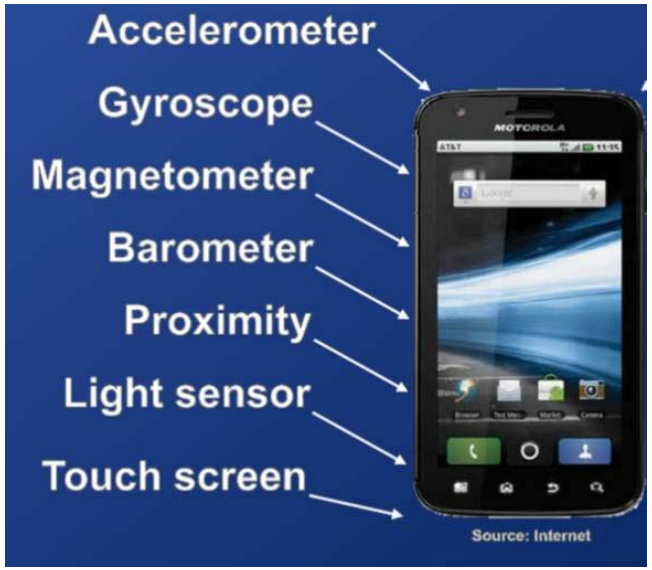
Smartphone & IOT driving growth in sensors and transducer technology

1) Increased sensitivity
2) Smaller sensors
3) Lower cost
4) Wireless

<u>Industrial Wireless Sensor now fastest growing in sensors with a CAGR of 38%</u>

Sensor Startups

- 271 Companies started in past 5 yrs



Example = New Differential Pressure Sensor from AHR2017

For Cleanrooms, where might Control Systems be Specified

Construction Specification Institute

April 2016	Current Master Format Division
Division 01	General Requirements
Division 11	Equipment
Division 23	HVAC
Division 25	Integrated Automation
Division 26	Electrical
Division 27	Communications
Division 28	Electronic Safety and Security

Large Scale ECM & Controls Comparison

Quick example, based on a 1000 FFU based cleanroom in California with Advanced Controls: *Saves $91,000 per year*

Units	Product	Approx Price Each	Watts @90CFM	Electricity Cost kwh	Daily Use	Controls Saving	Yearly Operating Cost	10 Yr Total Cost
1000	LEAC 2x4 AC FFU	$950	170	$0.145	24	0%	$215,934	$3,109,340
1000	LEDC 2x4 DC FFU	$1,400	90	$0.145	24	25%	$85,739	$2,257,385

* Estimated Cost savings achieved by reducing cfm during periods of lower use

Additional merits and opportunities

1) *Local energy rebates and property tax reductions not calculated*
2) *ECM produces less heat, 1000 ECM FFU = huge HVAC cost-down*
3) *ECM improves machine performance reducing maintenance costs*
4) *Plus ECM motor life is typically 2 years longer*

Saving Energy Saves $

Fujikin-Carten

- Founded in 1970, Carten-Fujikin, Inc. has evolved into a global leader in the manufacture of high purity bellows and diaphragm valves earmarked for critical gas and liquid delivery systems. In addition to a wide array of high integrity valve products, Carten is also becoming a recognized fabricator of integrated gas systems installed in current generation of semiconductor process tools. With two manufacturing facilities (Cheshire, Ct. USA and Waterford, Ireland), and stocking locations through independent distribution in the US and East Asia, Carten is capable of serving customer needs on a global basis
- **Fujikin's advanced fluid and gas automatic control equipment, specialized gas control units, ceramic valves, ultra-high precision electrically-actuated needle valves, as well as ultra high purity valves and fittings are suitable for use in a wide range of discrete manufacturing and materials equipment and processes.**

McILVAINE

Lighthouse Measures Multiple Cleanroom Parameters

The Lighthouse Monitoring Systems (LMS Standard) is designed for "Contamination Control", which means that our measurement systems are capable of measuring "dirt" or "disruption" in a cleanroom. In Semiconductor cleanroom environments, the following parameters are often included in a real-time monitoring system:

- **Air particle counts:** for cleanroom dust classification measurements according to ISO14644
- **Liquid particle counts**: for purity determination of UPW systems, pipes, bathing and operating materials
- **Particle counting in process gasses**: for purity determination of pipes and POU
- **Surface particle counters**: for surface cleanliness and sedimentation
- **Temperature:** for cleanroom space and operating materials
- **Relative Humidity**: for cleanroom production areas
- **Pressure Differential**: for cleanroom production areas
- **Airborne Molecular Contamination:** for cleanroom environments (e.g. acids, ammonia, amines, "dopans" and solvents)
- **Vibration:** For Lithography installations
- **Brightness:** for cleanroom production areas
- **EMC:** For field strength measurements in process areas
- **ESD:** Discharge measurements in production areas

McILVAINE

MKS Instruments and Controls

- Fabricating semiconductor devices involves four broad processes: deposition, removal, patterning, and modification of electrical properties. MKS Instruments provides automation and control, as well as instruments to measure or enable flow/gas delivery , effluent management, traps
- MKS has developed a new complete Automation Platform solution along with a suite of Automation Control hardware and software configurable modules - that allow semiconductor and other industrial manufacturing customers to better automate their processes through computer-controlled automation and seamlessly integrate with existing MKS products to provide a complete solution.
- MKS' expertise in control technology enables manufacturers worldwide to operate with greater productivity and streamlined efficiency. MKS works closely with our customers to provide proven, real time solutions that save time and money, reduce inefficiencies and enable faster implementation.

Benefits of MKS Automation and Control Solutions:

- Seamless interface to MKS Subsystems and Instrumentation
- Advanced analytics for improved process control - tuning, optimization, monitoring, troubleshooting, & fault detection which optimizes utilization of existing tools & assets
- Enables faster implementations and improves time to market
- Scalable and expandable, supporting many fieldbuses & control networks
- Lowest total cost of ownership compared to standard off the shelf systems & controls
- MKS Advanced Services offered for integrated testing, & training and recipe development

McILVAINE

MKS Microwave Plasma Subsystems

- Microwave applications include coating, etching, stripping, cleaning, surface modification in semiconductor and thin-film applications; vacuum heating, vacuum drying, pre-cooking, pasteurizing and sterilizing in food processes; curing, gas recombination, synthesis for chemical and pharmaceutical industries and diathermy, the treatment of biological tissues in medical application.
- Remote microwave plasma disassociates a wide range of semiconductor process gases to their atomic form. Applications include hydrogen for native oxide etch, fluorine for silicon etch, oxygen and nitrogen for oxidation and nitration to increase the dielectric constant of gate oxides. Atomic oxygen is widely used for high-rate, damage-free photoresist removal, and atomic fluorine effectively eliminates hard photoresist. Water vapor plasma successfully removes residue and aids post-metal etch passivation. With high selectivity and minimal dielectric damage, microwave plasma strip processes meet the cleanliness and residue removal requirements of fine device architectures, high aspect ratios and new low-k materials. An ion-depleted downstream microwave plasma has proven superior for achieving a pure dry chemical process and in dual-damascene low-k processes.
- In remote microwave plasma subsystems, the plasma discharge is used to dissociate process gases and produce active atoms (radicals) upstream of the process chamber. Remote microwave plasma subsystems produce a low content of energetic ions. Therefore, the flow of radicals generated in the microwave plasma source can be used for damage-free wafer processing
- MKS Instruments ® AX2600 and AX2700 Series Microwave Plasma Subsystems are complete, ready-to-integrate microwave plasma solutions. These microwave plasma delivery systems include the AX2500 SmartPower® Microwave Generator, SmartMatch®Tuner, Isolator, and AX7610 Microwave Applicator.
- Based on MKS' highly reliable, field-proven microwave plasma technology, AX2600 and AX2700 Series microwave plasma solutions deliver highly concentrated atomic species.
- Suitable for multiple chemistries, the high speed and precision of MKS plasma system automatic tuning guarantee immediate ignition and fast transition from plasma conditions for high productivity.
- Robust closed loop control ensures high accuracy, precision and optimal repeatability of the process from wafer to wafer and system to system.

McILVAINE

PureAir Monitoring Systems provides Oxygen Monitoring where Low Levels must be Measured

- Oygen monitor for use in semiconductors, clean rooms, and laboratories using glove boxes or small chambers. Typically, the glove boxes are inert environments using nitrogen. The monitor can be used for low level oxygen readings of 5% or less. Instead of trying to maintain a breathable oxygen level, the goal is to monitor a low level in a maintained environment. It is also used in laboratories where periodic cleaning of FOUPs is performed in a nitrogen environment.
- Easy to operate, the O2 monitor‘s joystick controls an audible alarm with visual alarm indicators. The instrument uses a local display and can be linked to fire alarm systems.
- The monitor requires no maintenance or calibration due to its non-depleting long life sensor. Built in “supervised watchdog” software continuously monitors all instrument functions 24/7. PureAire’s Oxygen monitor is not affected by humidity, temperature, or changes in barometric pressure. Rapidly changing barometric pressure from thunderstorms will not disrupt PureAire’s oxygen deficiency monitor. The majority of oxygen monitors sold use depleting electrochemical sensors that require frequent maintenance and calibration. PureAire’s Oxygen monitor can save up to $400 annually in replaceable sensors.

McILVAINE

TSI Facility Monitoring System

- TSI FMS system is an advanced monitoring software suite that features a truly distributed architecture. High availability databases and hot standby system failover functionality assures compliance and peace of mind. Standard inputs include: airborne particle counters (multiple manufacturers supported), temperature/humidity, differential pressures, air velocity and digital inputs. Any device that has a linear analog output can be integrated into FMS.
  Built-in system and database redundancy for compliance and peace of mind

Features

- Particle counter data buffer redundancy for unexpected communications failure
- Secure, high availability, high speed SQL databases enables real-time mirror database back up
- Buddy option, complete system automatic failover functionality on computer failure, no manual intervention required
- Meets all regulatory guidelines for GMP lifescience applications:
- Fully GAMP® compliant
- Enables 21 CFR Part 11 compliance
- Intuitive operation ensures the right information reaches the right people:
- Alarm display, notification (email. SMS and telephone) and acknowledgement
- User configurable system views, status windows and multi-level maps
- Demonstrates compliance using powerful user defined reporting, auto reporting and easy data export tools
- AeroTrak 9001 Cleanroom CPC enables electronic manufacturers to improve their production yields by allowing the detection and accurate monitoring of nanoscale particles (<100nm) in cleanroom manufacturing processes.

McILVAINE

UCT-Turnkey Chemical and Gas Delivery Systems

UCT's chemical and gas delivery systems ensure that Gordon Moore's prediction about ever-shrinking transistors will continue to be realized. The systems are configured to address your specific needs with superior technical expertise in design and manufacturing. Our turnkey systems permit the precise delivery, management and control of specialty gasses and chemicals – in semiconductor, flat panel, solar and medical manufacturing.

Using state of the art testing equipment developed by UCT's test engineering team, expert technicians ensure that your systems will meet your stringent performance requirements.

CHEMICAL DELIVERY

- Production of plastic chemical delivery systems has been the focus of UCT's Miconex division since the beginning more than 15 years ago. We understand and address the complexity of repeatedly and reliably delivering the liquid chemicals and precursors for your equipment requirements. Our expert welders, using state of the art production methods, fabricate the small sub-systems you need as well as large all plastic cabinets and exhaust channels.
- UCT's welding professionals routinely work with all forms of plastics including PP, PVC, CPVC, PVDF, PFA, and other FM 4910 approved materials. Utilizing leading edge welding capabilities, including infrared welding and hot gas welding, we ensure the integrety of your chemical delivery system. We have a segregated, fully equipped production area for welding PFA materials. Our welding process is certified with CSN 05 0705 (050705). The weldments are leak tested using Helium pressure tests and electrical permeability tests (spark tests). Fabricated parts are subject to digital 3D measurement inspection.
- These weldments are integrated by UCT's highly skilled manufacturing team with necessary high purity PFA pipe tubing and precision PFA tube bending on our class 10,000 production floor to provide your chemical delivery system modules and subsystems.

GAS DELIVERY

- As the semiconductor industry's first turnkey gas delivery system manufacturer, UCT lead in enabling the outsourcing strategy of the industry. Our business model was developed around highly configurable nature of semiconductor equipment manufacturing and we understand your requirements for precise delivery, management and control of specialty gasses and chemicals—also applicable to flat panel, solar and medical manufacturing. Our expert engineers are available to assist you with full gas delivery system design or design for manufacturing recommendations.
- UCT is the global leader in Ultra-High Purity (UHP) orbital and hand welding. Our rigorously trained welding professionals apply the latest techniques and technologies to ensure perfect welds every time. Our broad range of capabilities include small to large diameter fabrication, orbital welding, manual welding, and precision tube bending. By combining robotics welding with hand craftsmanship, we have moved the art of high purity welding and orbital welding to a robust manufacturing science.
- With final assembly in our class 100 and 1000 clean rooms, UCT's expert technicians ensure your gas delivery system will meet the stringent cleanliness that today's leading edge processes require.

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