MULTI-POINT CLEANROOM MONITORING

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ABSTRACT

The feasibility of installing a multi-point particle monitoring system in the Rochester Institute of Technology Class 1000 Cleanroom at work level was examined. This consisted of monitoring 10 separate locations in the cleanroom at work level, including flow hoods, processing equipment and room air. An RS1 procedure was written to generate control charts and count information. The results showed that during low and high activity at a station the particle counts were in and out of process limits, respectively. Recommendations were made concerning installation of a complete system.

INTRODUCTION

Failure analysis of Integrated Circuits has shown that in Semiconductor Processing, particles one-tenth the smallest geometry can be hazardous to successful IC operation [1]. At RIT the minimum geometries in a standard process are 5 microns, and decreasing. Therefore, particles sizes of .5 microns and smaller must be controlled.

Cleanroom cleanliness is broken into several catagories, according to Federal Standard 209D on clean rooms [2]. The general misconception is that only the number of .5 micron particles per cubic foot of air determines the room rating. In fact, several particle sizes should be used, especially in rooms with gross particle generators such as paper. The Class 1000 specification may be met at the .5 micron size (1000 particles percubic foot), but it may not be met at the 5 micron size (7 particles per cubic foot). It is for this reason that several particle size ranges should be monitored.

The Hiac/Royco 4150 A particle counters (X) are capable of monitoring airborne particles as small as 0.5 microns, and two units have the potential to measure 0.3 micron size particles. These counters can also be used to monitor particles in process gases and liquids. The 0.5 micron counters use standard optical particle counting methods to detect particles. As particles pass through the focal plane of the optical system, a white light beam is focused on the particles which causes light scattering according to particle size. The scattered light is collected by another optical system and a corresponding voltage level is triggered by a Photo Multiplier Tube. This is known as a white

light, or incoherent light optical particle counter. Counters with laser sources are known as laser counters or coherent light optical particle counters.

The optics system has a limit to the number of particles that can be measured without error. If too many particles are sampled by the counter the optics will count several small particles as one large particle. This is known as coincidence error, or coincidence loss. For the Hiac/Royco counters the threshold value for coincidence loss is approximately 300,000 particles per cubic foot [4].

Another area of concern is the flow rate of the counters. The factory setting is 1 cubic foot per minute (+ or - .5 CFM) [4]. This amount of error can cause serious descrepancy in the number of counts recorded because different flow rate counters do not produce identical counts for the same cleanliness levels. To minimize this error, long count times should be used (1 minute samples). In a one minute sample, ideally one cubic foot of air would be sampled. If 6 second samples were taken and multiplied by 10, the error in flow rate, and correspondingly the number of counts, would be also multiplied by 10.

One must also examine the sampling tube length. If the tube length is greater than 50 feet, severe particle dropoff will occurr in the tube due to gravitational effects. This results in less than actual particle counts at a given location. The larger the particle size, the more severe the dropoff effects. For the purposes of this project the maximum length will be approximately 25 feet. Even at this length, large particles will be captured in the sampling hose, but the critical .5 micron size particles should still reach the counter.

Proper particle monitoring is done at the work level to determine the cleanliness of a given process. If equipment restraints do not allow for at level monitoring, then the equipment should be monitored as close to the center of operations as possible. Also, monitoring should be done well above the floor since most clean rooms have an 18 inch gross particle zone at floor level. The Laminar flow of a well designed cleanroom should prevent these particles from contaminating a process. The RIT cleanroom has sidewall returns, but with enough Laminar flow to sweep particles away from workstations.

X-Donation by Fairchild Semiconductor Corporation

EXPERIMENT

Ten hoses were installed to obtain preliminary particle count data. The hoses were extended from the counter set-up in a service chase. The monitored locations included several flow hoods, wafer cleaning equipment, a computer terminal, chemical cabinets and room air. Many of the specific locations, such as the computer terminal, were chosen because the jump from low to

high particle counts occurs rapidly. Most of the hoses were been run under the service chase floor so as to be unobtrusive. There is still a concern as to how the long hose lengths will affect the particle counts. The longest hose is approximately 22 feet long, and the shortest is approximately 15 feet long.

Prior to this specific project a FORTRAN communications program was written that allows for remote operation of the counters. The program controls the operating parameters of the counters, such as sampling time, and also collects and stores the particle count data. Data is stored for particles >0.5 um, >1.5 um and >5.0 um for each of the 10 locations, with 30 samples per location.

For this project an RS1 procedure was written that generates control charts and other particle count information. This procedure retrieves the particle count data from the VMS files, prompts the user for which station is to be examined, generates and stores the mean and standard deviation of the location, and creates a report that provides information on the number of points inbounds, the specific particle count for a given sample time, the mean and the standard deviation. The program then uses the data to create a control chart of particle counts vs. sample number (with 4 minutes between samples). An example of the control charts is shown in figure 1.

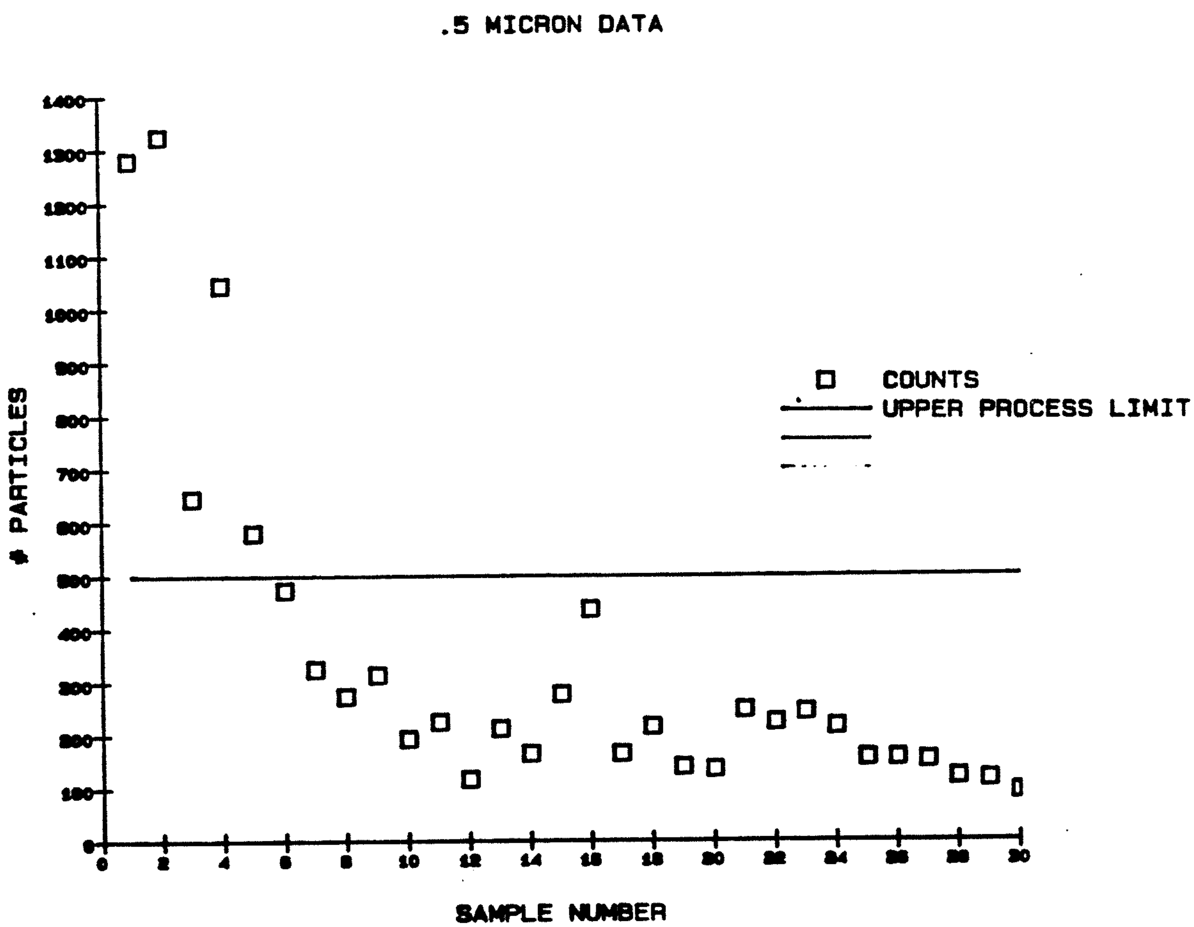


Figure 1: Control Chart example

RESULTS/ANALYSIS

From the data that has been obtained, it appears that the contamination levels for the RIT cleanroom during low activity are well below the process limits, as shown in figure 2. However, as shown in figure 3 , while the low activity counts are well under control the high activity counts are out of control. If we also examine the mean chart, in figure 4, the contamination again appears to be in control overall. However, please notice the one outlying point on the mean graph. This point is the mean of particle counts taken during high activity at that location. This indicates that while the background, or low activity, contamination is in control, the actual processes are quite dirty. This general trend appears for >1.5 um and >5.0 um particle ranges as well.

Figure 2:

Control Chart during low activity

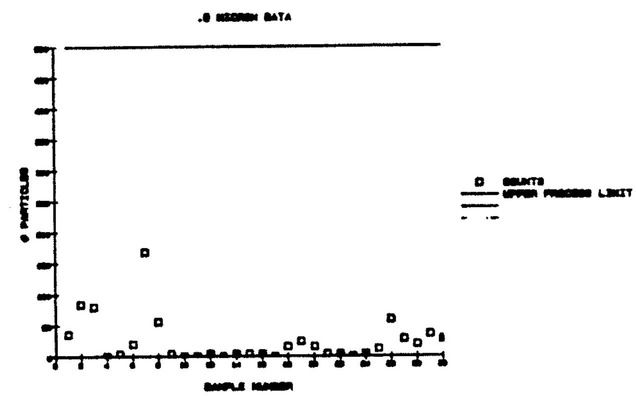


Figure 3:

Control Chart during high activity

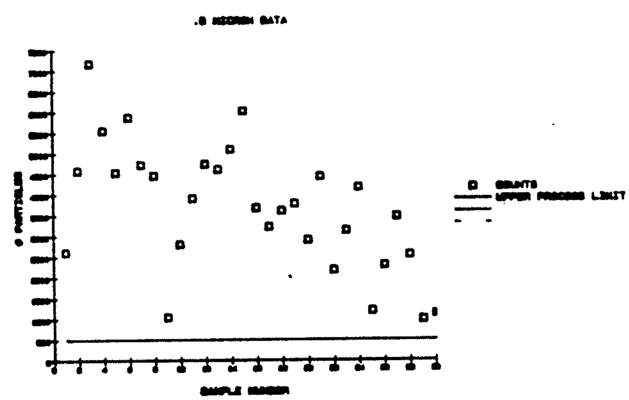
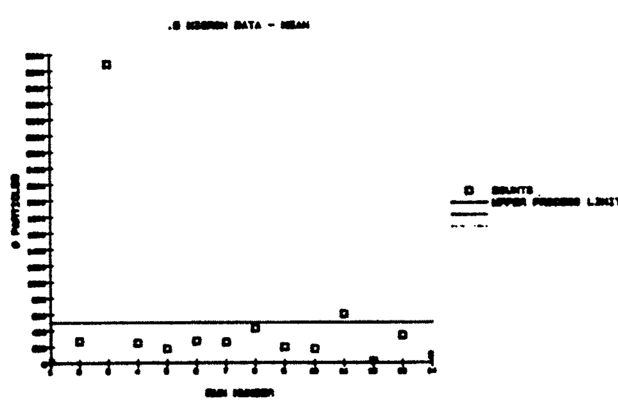


Figure 4:

Control Chart of the Means



A small report on each sample set was also generated by the RS1 procedure. As seen in figure 5 this report provides information on the Mean value, the number of points out of bounds, and the individual particle counts for each sample.

0;1218M Limits table for

0;1190M control chart: CCHART

0;1134M	0 SUBGROUP ID	1 SUBGROUP NUMBER	2 Nonconformities	3 USL	4 TAR	5 LSL	6 DATE
0;1050M	1	1	1280	500	0	0	08-MAY-89
0;1022M	2	2	1324	500	0	0	08-MAY-89
0;994M	3	3	644	500	0	0	08-MAY-89
0;966M	4	4	1044	500	0	0	08-MAY-89
0;938M	5	5	580	500	0	0	08-MAY-89
0;910M	6	6	472	500	0	0	08-MAY-89
0;882M	7	7	324	500	0	0	08-MAY-89
0;854M	8	8	272	500	0	0	08-MAY-89
0;826M	9	9	312	500	0	0	08-MAY-89
0;798M	10	10	192	500	0	0	08-MAY-89
0;770M	11	11	224	500	0	0	08-MAY-89
0;742M	12	12	116	500	0	0	08-MAY-89
0;714M	13	13	212	500	0	0	08-MAY-89
0;686M	14	14	164	500	0	0	08-MAY-89
0;658M	15	15	276	500	0	0	08-MAY-89
0;630M	16	16	436	500	0	0	08-MAY-89
0;602M	17	17	164	500	0	0	08-MAY-89
0;574M	18	18	216	500	0	0	08-MAY-89
0;546M	19	19	140	500	0	0	08-MAY-89
0;518M	20	20	136	500	0	0	08-MAY-89
0;490M	21	21	248	500	0	0	08-MAY-89
0;462M	22	22	224	500	0	0	08-MAY-89
0;434M	23	23	244	500	0	0	08-MAY-89
0;406M	24	24	216	500	0	0	08-MAY-89

```
3F9;28S
0H
0;1274MReport for chart: CCHART
0;1218MType of control chart: .5 MICRON DATA
0;1162MMethod of determining control limits:
0;1078MUser-specified Values for TAR, USL, and LSL.

0;1022MSUMMARY:
0;966MFrom X = 1 to X = 30:
0;938M     Date: 08-MAY-89
0;910M     USL = 500
0;882M     TAR = 0
0;854M     LSL = 0
0;798MTotal of 30 groups; 5 groups out of bounds
0;770M     (5 > USL; 0 < LSL)
0;742M17% out of bounds
0;714M     (17% > USL; 0% < LSL)
```

Figure 5: Report on data

Based on the collected data several recommendations are made. First, sample times of 15 seconds should be sufficient to sample. This allows enough time for the counters to minimize flow rate concerns previously mentioned and reduces the sample time between counts to four minutes. Also, each location should be monitored every day, but charts need only be generated once per week. This will require changes in the FORTRAN communications program output files in order to store one full day of data. As far as sampling locations, a list of locations is in the appendix. Also, the hoses should not be bend at more than a 90 degree angle; this minimizes particle drop-off in the tube. The tubes should be changed when visibly dirty. At each chosen location the hose should be as close to process level as possible, without interfering in processing. If this is not possible, the hose should try to be placed in the particle path of the area of interest (this is usually directly below a certain station). Also, the counters need to be calibrated and correlated to one another to ensure consistent particle counts.

CONCLUSIONS

Ten sampling hoses were installed at 10 locations and monitored for airborne particle counts. Results show that during low activity at a location the particle counts were within acceptable limits. However, during high activity, the particle counts were outside the acceptable limits. Recommendations were made for the completed system, and this will require changes in the FORTRAN program that remotely operates the counting systems.

ACKNOWLEDGEMENTS

Brad Moore wrote the communications program connecting the VAX and the particle counters, Steve Wilkins helped with RPL procedures, John Carlberg of Eastman Kodak assisted with proper particle monitoring techniques, and Bruce Smith of RIT lent his QCA manual.

REFERENCES

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[2] "Federal Standards for Clean Room and Work Station Requirements, Controlled Environments", Journal of Environmental Sciences, 9/88.

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[4] "Operations and Service Manual", Hiac/Royco 4150 Systems manuals.