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Measurement of Nanoparticles on Parts: Figures of Merit of a Liquid-borne Particle Counter

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Abstract

- Measuring surface particles extracted from parts by liquid-borne particle counter (LPC) effective in evaluating surface cleanliness of semiconductor tool components (parts)
- Extended previous framework for evaluating commercial LPCs to a LPC counting particles smaller than 200 nm with close to 65% counting efficiency
- Evaluated counting accuracy, precision, stability, and limit of detection, among others, of a commercial LPC
- Counting efficiency not considered, counting accuracy <70% from results based on PSL count standard
- After counting efficiency correction, counting error <3%. Measured imprecision ≤3%. The linear dynamic range from 15 to 1,000 particles/mL.

Results

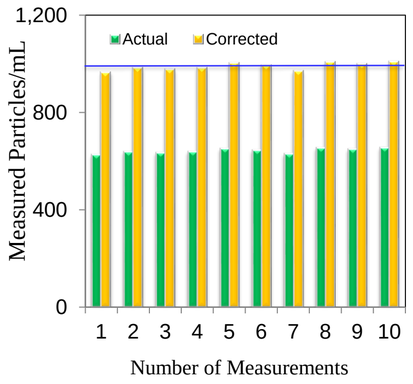

Fig. 1. Counting accuracy evaluated by measuring a PSL count standard. Ten measurements of count standard (0.231µm nominal size, certified value 1,002 particles/mL) average 642 particles/mL. Without counting efficiency correction, accuracy based on this result is 64%; after correction, accuracy is 98.6%.

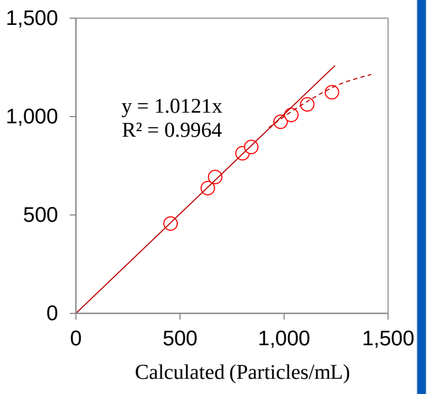

Fig. 2. Linear dynamic range determined with a set of dilutions made from a quartz extract. The calculated concentrations range from 400 to 1,200 particles/mL. Measured linear dynamic range from 15 to approximately 1,000 particles/mL. Measured concentrations above this range start to deviate.

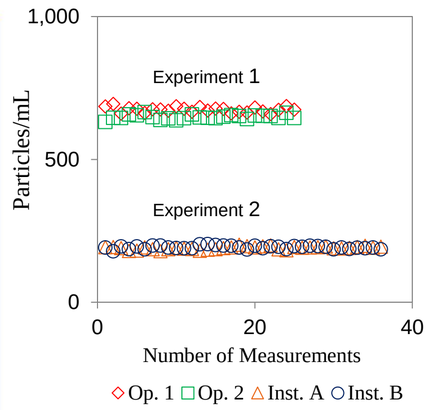

Fig. 3. Measurements showing high precision of this counter. 25 repeated measurements in Experiment 1 and 35 repeated measurements in Experiment 2. Both experiments show ≤3% imprecision.

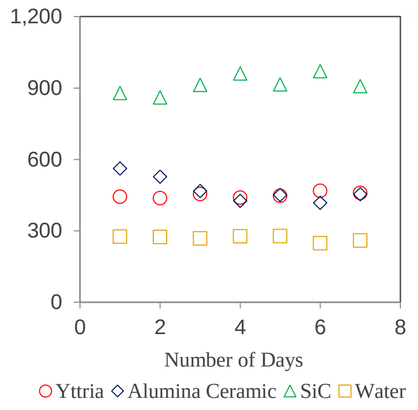

Fig. 4. Extracts of different materials measured for stability. Water and yttria extracts were relatively stable; SiC extract stable after Day 2; Alumina extract different everyday.

Table I: Spike recovery experiments performed by spiking a water sample with different extracts, respectively. Both spiked and unspiked samples were measured. Spike recoveries range from 92% to 119% for particle concentrations above 15 particles/mL (LOQ).

Material	Spiking Level (particles/mL) / Recovery (%)				
	≥ 0.1 µm	≥ 0.15 µm	≥ 0.2 µm	≥ 0.3 µm	≥ 0.5 µm
Quartz	884	298	129	25	6
	99%	99%	98%	92%	67%
Yttria	1064	475	235	51	12
	102%	103%	105%	107%	101%
Al_2O_3 Ceramic	1107	443	208	44	5
	101%	105%	108%	119%	139%
Doped Yttria	757	452	293	121	41
	108%	107%	106%	109%	112%
Aluminum	954	494	286	99	30
	108%	110%	110%	108%	98%

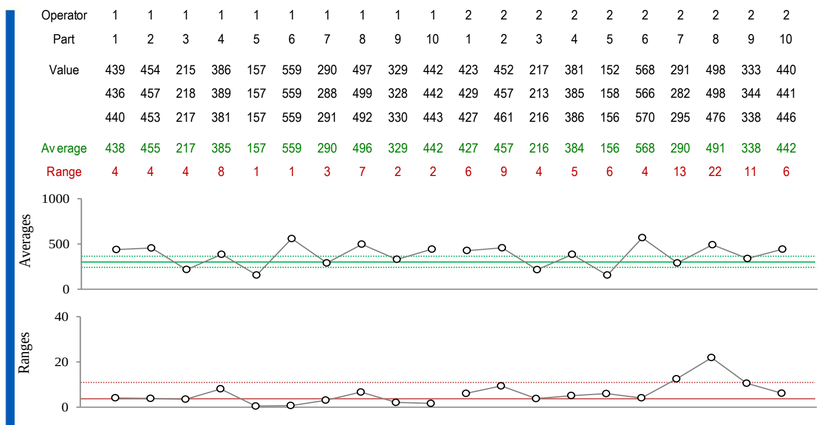

Fig. 5. Gage R&R performed per EMP III with ten different extracts. Extracts measured by two operators in triplicate for a total of 60 measurements. According to EMP III, the measurement process is a "first-class monitor"

Conclusion

- Counting efficiency affects measurement accuracy
- Linear dynamic range different from manufacturer spec of maximum 1,200 particles/mL
- Evaluating surface particles extracted from parts by LPC is effective only if LPC is fit for particle contamination measurement.
- Each LPC might have a different counting efficiency, direct comparison of uncompensated result is meaningless.
- The effect of counting efficiency on different counters and different materials will be studied in further details in future work.

References

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