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Atmospheric Measurement Techniques Discussions

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Interactive comment on "MEMS-based condensation particle counter for real-time monitoring of airborne ultrafine particles at a point of interest" *by* Seong-Jae Yoo et al.

Anonymous Referee #1

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General:

The manuscript of Yoo et al. presents design of a MEMS based CPC, its manufacturing process, and cut-off and concentration response characterization. The CPC design, to my knowledge, is unique and certainly deserves publication in AMT. Compared to commercial CPCs, the MEMS CPC reduces the size and weight significantly. The description of the manufacturing process seems adequate although outside of my expertize. Some claims are made on the cost-effectiveness of the CPC, which, however, should be considered carefully until the CPC is actually sold, as the final price of the CPC depends on many things, which are not discussed here, such as production

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volumes, company structure etc. Possibly material costs can be compared if you get that information from other manufacturers, which I doubt. Indeed, I believe this manufacturing method can possibly be cheaper than the current designs, while the current manuscript does not support that with numbers.

The experimental characterization of the CPC is adequate, while the authors do not consider carefully enough why the cut-off is 13 nm. For example, according to its manual, TSI 3775 has temperatures of 39C in the saturator and 14C in the condenser, compared to 40C and 10C in the MEMS CPC. With smaller dT, the cut-off of the 3775 is 4 nm, while the MEMS CPC cut-off is 13 nm. TSI 3772 has cut-off of 10 nm at dT of 17C. How come? Even the Kelvin diameter inside the MEMS CPC is calculated to be 2.45 nm. Satisfactory explanation for this should include discussion and/or experiments and/or modeling of particle losses inside the CPC, the capability of the saturator to fully saturate the flow, and the condenser supersaturation profile. This should help to understand why the cut-off is 13 nm and not 2.45 nm what the Kelvin diameter predicts. Indeed, in careful experiments it has been found that the Kelvin diameter overestimates observed the cut-off, e.g. Iida et al. (2009) and Winkler et al. (2008).

Minor comments

P1 l18, i would not consider particle concentration of 7000 cm-3 as “high concentration” environment. The concentrations range from 10ˆ0 in clean environments to 10ˆ6-7 in very polluted or industrial applications, so 10ˆ4 somewhere in the middle

P1 l20-25, There are various sources of UFPs, such as secondary particle formation in the atmosphere from the existing gases. Also their fraction of the total concentration is highly specific to the environment, or measurement time

P1 l29-30, “High-precision industries with cleanrooms also need UFP monitoring to increase the production yield”, what does this mean? How is UFP and production yield connected?

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P1 l34-36, why does it need to be portable or low-cost? Any “normal” CPC will give the same information

P2 l1-2, “because they are theoretically capable of counting every single UFP”, this could be reformulated a little bit. Why e.g. your CPC is limited to concentration around 7000 cm-3 or smallest size of 13 nm? Same theoretical limitations apply for other CPC designs, just resulting in different limiting numbers.

P2 l3-4, “64 size channels per decade”, from where this number is obtained? With a DMA you can in practice select almost infinite number of size channels

P2 L39, is the OPC also homemade or commercially available?

P4 l15-17, what is the difference between TSI Co. Ltd. and TSI Inc.?

Section 5.1, it is not evident whether there was a flow above the butanol surface when the dry-out region was measured. If not, does the flow have any effect on the dry-out region formation?

P5 l17-20, reformulate the sentences, partly badly written, partly ambiguous. “Initially” refers to A happening before B. The next sentence is ambiguous, what is the supersaturation that you calculate the Kelvin diameter? There is a supersaturation profile in the condenser, so single value for the Kelvin diameter is not good, unless it is a particle trajectory weighted average or something similar. Also 5 and 9 nm are quite much above the calculated Kelvin diameter, so why at 9 nm it increases sharply and not above 5 nm?

P5 l23, I would say non-negligible. If the Kelvin diameter is 2.45 nm, how come 90% of particles are detected only at 20 nm?

P5 l30, please indicate the background count rate also in units of count every x seconds. If these background counts are originating from homogeneous nucleation, it should already hint you why the cut-off of your CPC is so far away from the Kelvin prediction

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P5 l30-32, reformulate. Temperature profile does not necessarily have anything to do with homogeneous background counts. It is true that homogeneous nucleation takes place at regions of high saturation ratio, but the temperature does not matter in case the saturation ratio is high enough.

P5 l32-P6 l6, does the concentration ratio CPC/AEM plateau immediately above concentrations of 7000 cm-3? With some corrections the CPC is possibly usable also at concentrations higher than 7000 cm-3.

P6 l10, why averaging of 6s? is the CPC performance comparable at 1s resolution?

P6 l22, what is the price of your CPC? Or manufacturing price (materials or materials+work) compared to manufacturing price of some other commercial CPC? I would be careful in making claims about cost-effectiveness without these numbers

P6 l23, 91.5% of what? Price, weight, volume?

Fig1, something missing from Air inlet (0.15

Fig4, why in the picture of aerosol electrometer reads condensation particle counter, and in the reference CPC reads electrometer?

References

Iida, K., Stolzenburg, M. R., McMurry, P. H. (2009). Effect of Working Fluid on Sub-2 nm Particle Detection with a Laminar Flow Ultrafine Condensation Particle Counter. Aerosol Sci Tech 43:81-96.

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