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Study on Calibration Methods of Discharge Coefficient of Sonic Nozzles using Constant Volume Flow Meter

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This paper address technical issues in calibrating discharge coefficients of sonic nozzles used to measure the volume flow rate of low vacuum dry pumps. The first challenging issue comes from the technical limit that their calibration results available from the flow measurement standard laboratories do not fully cover the low vacuum measurement range although the use of sonic nozzles for precision measurement of gas flow has been well established in NMIs. The second is to make an ultra low flow sonic nozzlesufficient to measure the throughput range of 0.01 mbar-l/s. Those small-sized sonic nozzles do not only achieve the noble stability and repeatability of gas flow but also minimize effects of the fluctuation of down stream pressures for the measurement ofthe volume flow rate of vacuum pumps. These distinctive properties of sonic nozzles are exploited to measure the pumping speed of low vacuum dry pumps widely used in the vacuum-related academic and industrial sectors.Sonic nozzles have been standard devices for measurement of steady state gas flow, as recommended in ISO 9300. This paper introduces two small-sized sonic nozzles of diameter 0.03 mm and 0.2 mm precisely machined according to ISO 9300. The constant volume flow meter (CVFM) readily set up in the Vacuum center of KRISS was used to calibrate the discharge coefficients of the machined nozzles. The calibration results were shown to determine them within the 3% measurement uncertainty. Calibrated sonic nozzles were found to be applicable for precision measurement of steady state gas flow in the vacuum process. Both calibrated sonic nozzles are demonstrated to provide the precision measurement of the volume flow rate of the dry vacuum pump within one percent difference in reference to CVFM. Calibrated sonic nozzles are applied to a new 'in-situ and in-field' equipment designed to measure the volume flow rate of low vacuum dry pumps in the semiconductor and flat display processes.