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Model Development to Predict Mass Transfer of Particles onto a Flat Plate in Parallel Airflow

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Extended Abstract

Mass transfer of particles onto a wafer may result in the failure of the wafer in semiconductor manufacturing. The contamination control of particulate mass transfer is therefore of great importance to enhance the yield. In order to effectively reduce the particulate contamination of the wafers, it is needed to predict the level of the particulate contamination in clean room environments. The level of the particulate contamination of a critical surface can be assessed in terms of the deposition velocity, which means the number of particles deposited on the surface per unit time per unit surface area and per particle number concentration above the surface (Bae et al., 1995; Lee et al., 2014; Opiolka et al., 1994; Woo et al., 2012). For example, with the consideration of the Brown diffusion and gravitational settling of particles, the deposition velocity can be predicted by summing the mean mass transfer coefficient and the settling velocity of particles (Liu and Ahn, 1987). However, in case when the particle motion is affected by an electric field and/or a thermophoretic force, the deposition velocity cannot be simply obtained. In this study, the Gaussian Diffusion Sphere Model (GDSM) suggested by Yook and Ahn (2009) was developed to estimate the deposition velocity of particles onto a flat surface, simulating a wafer, exposed to parallel airflow, by considering the effects of the Brownian diffusion, gravitational settling, and electrical drift in an electric field, and thermophoretic drift of particles in a temperature gradient. The GDSM was validated by comparing the deposition velocity calculated by the GDSM with the deposition velocity predicted by simulating the flow field and particle trajectories. The GDSM was found to be accurate and fast in estimating the deposition velocity onto the flat plate in parallel airflow.

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Bae, G.N., Lee, C.S., & Park, S.O. (1995). Measurements And Control Of Particle Deposition Velocity On A Horizontal Wafer With Thermophoretic Effect. *Aerosol Science and Technology,* 23, 321−330.

Cengel, Y.A. (2003). Heat transfer 2nd edition. Mc Graw-Hill.

Lee, H., Yook, S.J., & Lee, K.S. (2014). Deposition Of Charged Particles On A Flat Plate In Parallel Flow In The Presence Of An Electric Field. *IEEE Transactions on Semiconductor Manufacturing,* 27, 287−293.

Liu, B.Y.H., & Ahn, K.H. (1987). Particle Deposition On Semiconductor Wafers. *Aerosol Science and Technology,* 6, 215−224.

Opiolka, S., Schmidt, F., & Fissan, H. (1994). Combined Effects Of Electrophoresis And Thermophoresis On Particle Deposition Onto Flat Surfaces. *Journal of Aerosol Science,* 25, 665−671.

Woo, S.H., Lee, S.C., & Yook, S.J. (2012). Statistical Lagrangian Particle Tracking Approach To Investigate The Effect Of Thermophoresis On Particle Deposition Onto A Face-Up Flat Surface In A Parallel Airflow. *Journal of Aerosol Science,* 44, 1−10.

Yook, S.J., & Ahn, K.H. (2009). Gaussian Diffusion Sphere Model To Predict Mass Transfer Due To Diffusional Particle Deposition On A Flat Surface In Laminar Flow Regime. *Applied Physics Letters*, 94, 191909.