PARTICULATE CONTAMINANT FORMATION
AND TRANSPORT IN MICROELECTRONIC
MANUFACTURING PROCESSES

Phase II Quarterly Report

by

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CFD Research Corporation

and

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CFDRC Report: 4396/7

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1. **INTRODUCTION**

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1. to obtain and adapt models for particle charging, particle growth, and electrostatic and ionic drag forces on particles from Prof. Mark J. Kushner’s group at the University of Illinois Urbana-Champaign (UIUC);

2. to obtain and adapt models for ion-induced nucleation from Prof. Steven Girshick’s group at the University of Minnesota (UMN);

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4. to perform detailed parametric studies to assess the effects of various operating conditions on particle formation and transport;

5. to demonstrate the integrated model in collaboration with an equipment manufacturer to reduce/eliminate particle effects in a processing system;

6. to transfer the technology to the industry in collaboration with SEMATECH and its member companies; and

7. to prepare a final report documenting the work performed during the Phase II study.

1.2 **Project Status**

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1.3 Overview

Section 2 describes progress made on the particle transport model by the University of Illinois sub-contractor. Section 3 describes progress made modeling nucleation pathways for use with the moment model as reported by the University of Minnesota sub-contractor. Section 4 discusses modifications made by CFDRC to the moment model. Section 5 discusses the future plans for the CTGS tool development.

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The Sandia SPIN code was used to obtain results with two different chemical mechanisms: (1) the gas-phase and surface mechanism recommended by Ho et al. (1994), and (2) the simplified kinetic mechanism used by CFDRC. Both mechanisms were tested using SPIN. While the results were similar in most respects, some significant discrepancies were found, for example the predicted hydrogen concentration differed by about two orders of magnitude for the two different chemical mechanisms. In contrast the two different numerical schemes (either CFD's or SPIN) produced quite similar results when the same chemical mechanism was assumed.

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4. MOMENT MODEL

The moment model at CFDRC has undergone modification. The code now specifies material properties through the input file instead of “hard-wired” in the code. Material properties include items such as monomer specie, monomer mass, particle density, particle conductivity, vapor pressure, and surface tension. The altered code facilitated testing the model with other material systems. Through testing tweaks to the source term were made to allow for convergence, such as limiting source terms to non-negative values.

5. FUTURE WORK

The current status of the project is shown in Table 5-1. Future work will address both areas of the technology transfer focusing on improvements to the transport, charging, and growth models.
Table 5-1. Status of Project Tasks

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<td>(iii) Preparation of Final Report</td>
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The moment model will incorporate the atomistic nucleation model as a source term. The possibility of forming a discrete-modal model will be explored. A discrete-modal model solves separate General Dynamic Equations (GDEs) for small clusters and the moments of the GDE assuming a lognormal size distribution for particles above a specified size. Coupling a discrete model with a moment model will be explored as an option.

The GUI for the charging and transport will undergo further testing. More efficient information sharing from ACE and PLASMA(ICP) code to the transport code will be explored such as through the restart files. The transport model which currently assumes monodisperse systems will be altered to transport more than one particle size at the same time. Other modifications which have yet to be finalized could include transport of nonspherical particles (i.e., flakes), accounting for particle coulomb-coulomb interactions,
making particle charging time-dependent, changing the charging model for smaller size particles, and allow for variance in size as particles collide with each other increasing in size or atoms evaporate off of the particle reducing its size.

REFERENCES


CFD RESEARCH CORPORATION  
Ref: ARPA Contract # MDA972-96-C-0003; CFDRC Project # 4396

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