



THIN FILM EQUIPMENT AND PROCESS MODELING WITH ACE+ SUITE

KEY BENEFITS

- **Integrated physics:** Accurate modeling of semiconductor manufacturing equipments and processes, helping to improve yield and equipment technology.
- **Robust CVD and plasma modules:** Increases productivity and provides an easy way to optimize uniformity.
- **Strong features evolution capability:** Enhances yield by analyzing results of the manufacturing process.
- **Electroplating model:** Improves new equipment design and metal deposition processes on existing equipment.
- **Access** to several in-built species and reaction database.
- **Knowledge capture** via advanced material databases.
- **Automated analysis** via scripting and optimization tools.

IN-BUILT APPLICATION MODULES

- Chemical Vapor Deposition (CVD)
- Chemical reaction mechanisms
- Electromagnetics
- ETCH
- Induction heating
- Electroplating
- Micro-scale features
- Plasma
- Radiation

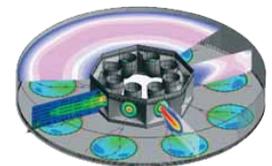
REACTOR MODELING

The thin film fabrication process involves complex equipments along with physical and chemical reactions. A thorough understanding of different physical and chemical phenomena and how they interact is vital for reactor design. ACE+ Suite provides the tool to model complex multiphysics processes for practically any type of reactor, to understand how the system functions, and to predict how changes will impact the design efficiency. With ACE+ Suite you can create individual modules that specifically address the physics and chemistry for each of these applications.

Chemical Vapor Deposition and ETCH

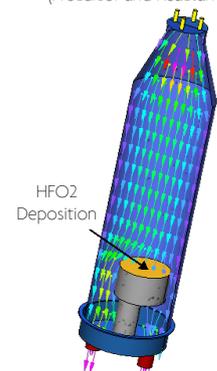
ACE+ Suite has an edge in the semiconductor industry for high fidelity simulation of deposition and etch of compound semiconductors. Capabilities of ACE+ Suite:

- Models most CVD, RTP, and ALD reactors;
- Simulates multi-component species transport with associated gas and surface reactions;
- Monte Carlo radiation model;
- Predicts the reactor's thermal environment including radiation effects, induction heating and thermal stresses;
- Includes slip boundary conditions for accurate simulation of non-continuum effects at low pressures or in rarefied regions (e.g. shower heads);
- Simulates shower heads, porous wall boundary condition;
- External radiation sources interfaces with feature evolution module;
- Exceptionally advanced stiff solvers for complex chemical mechanisms.



Planetary Reactor

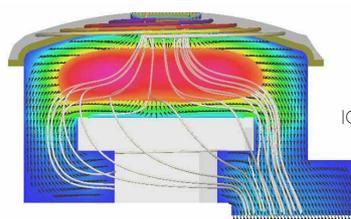
Delivery Ports (Precursor and Reactants)



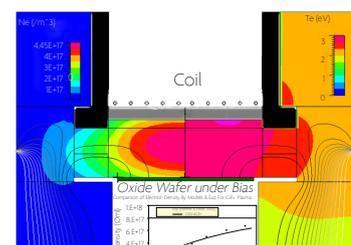
ALD Reactor

Plasma

ACE+ Suite combines plasma chemistry and transport with electromagnetic in an integrated environment for a wide range of thin film applications, from low pressure, non-equilibrium to thermal atmospheric plasmas.



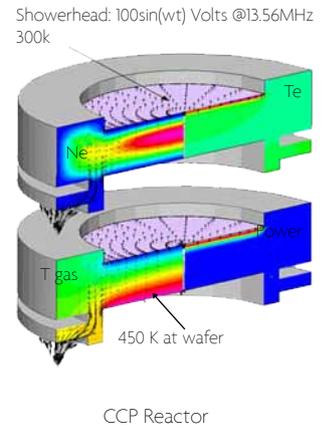
3D filament representation of coil



Validation study

The plasma module provides the following capabilities:

- Models of most types of thin film plasmas;
- Calculates deformation as well as wafer and chamber stresses via seamless coupling with FEMStress;
- Simulates electromagnetic power deposition, RF/DC bias and plasma enhanced reactions;
- Maxwellian and non-Maxwellian EEDF Electron kinetic for accurate prediction of electron properties and plasma;
- Electromagnetic wave effects including standing wave;
- Stochastic heating, Ion momentum, and other functionality;
- External circuit coupling;
- Interface with feature evolution module;
- Full 3D modeling;
- Simulates flow effects via tight coupling between gas flow and plasma transport;
- Calculates heat transfer and thermal balance for entire reactor.



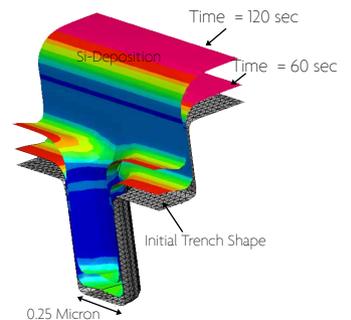
PROCESS SIMULATION

With ACE+ Suite, process engineers can analyze the effects of key parameters on the speed and quality of etching and deposition. Through the understanding of characteristics such as thermal uniformity and aspect ratios, you can assess the scalability of processes and determine the impact of each process step. These simulation capabilities allow for significantly reduced efforts in physical testing, resulting in shorter lead times and lower costs.

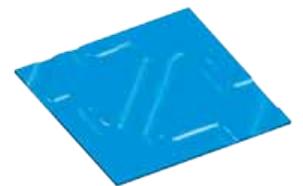
Feature Evolution

In order to accurately predict 3D shape evolution created by thin film deposition and etching of the wafer surface, CFD-TOPO can be used. CFD-TOPO is a simulation tool that predicts how the shape of objects changes due to the combined effects of chemical species transport and surface reaction in gas-solid interfaces. CFD-Topo's capabilities:

- Determines growth and etch rates as a function of time;
- Simulates any number of multi-step surface reactions, and changes in solid material shape due to chemical reactions;
- Models 2D and 3D shapes, and options for isotropic, angle, and energy dependant incident gas phase species flux.



Fine Feature Evolution: Deposition



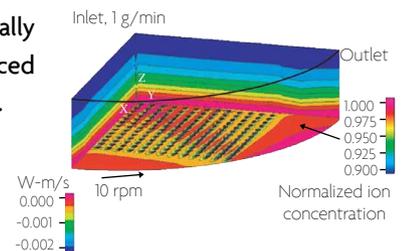
Fine Feature Evolution: Etching

Electroplating

When dealing with semiconductor processes, small features require more layers with special metal plating requirements. ACE+ Suite's electroplating module gives a better understanding of what is actually happening during these critical operations. Trial and error with physical prototypes can also be reduced by simulating the complete electroplating process, including the effect of complex electrochemistry.

ACE+ Suite's electroplating excels in the following functions:

- Models the effects of additives, pulse and pulse reverse plating on plating uniformity;
- Simulates multi-step surface reactions and multi-species electrochemical deposition;
- Models high-aspect ratio seed layers and transient growth of deposition layers on insulated substrates.



Impinging velocity and normalized ion concentration contours for 3D simulation of limiting current density in through-mask ECD applications

ABOUT ESI GROUP



ESI is a pioneer and world-leading provider in virtual prototyping that takes into account the physics of materials. ESI has developed an extensive suite of coherent, industry-oriented applications to realistically simulate a product's behaviour during testing, to fine-tune manufacturing processes in accordance with desired product performance, and to evaluate the environment's impact on performance. ESI's solutions fit into a single collaborative and open environment for End-to-End Virtual Prototyping, thus eliminating the need for physical prototypes during product development. The company employs over 800 high-level specialists worldwide covering more than 30 countries.

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