

Dynamic Simulation of Water Recycling in Semiconductor Manufacturing

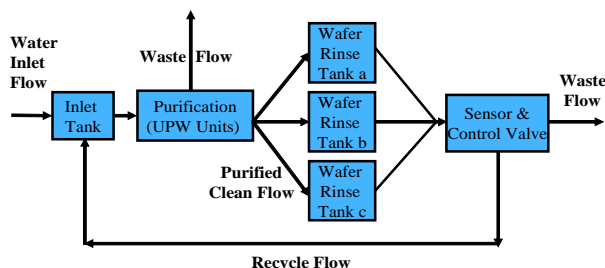
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Overview

- Physically-based dynamic simulation reveals time-dependent and time-integrated process behaviors:
 - Evaluate ESH, manufacturing and technology metrics change under process changes for integrated ESH assessment
 - Exploit simulation-based learning system: Water recycling process simulator (WaterSim)
- Apply to engineering analysis and optimization of water recycling systems, as done for CVD and ALD processes.
- Completely rebuild educational module for water recycling
 - More powerful and flexible simulation model
 - More advanced learning software platform (latest SimPLE)

Simulator Structure

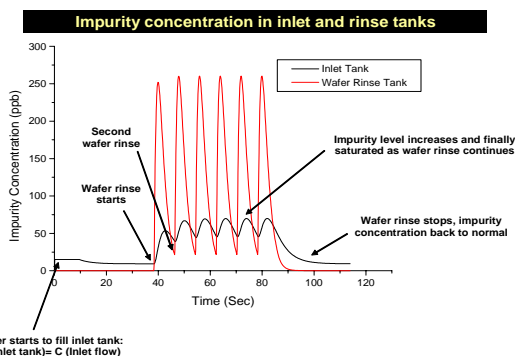


- New features:
- Interchangeable UPW unit models
 - Multiple rinse tanks
 - Multiple impurity species

Simulator Basic Features

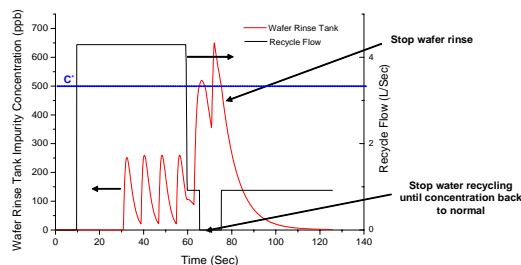
- Use of vector variables and embedded function for structural simplification/organization;
- Multiple and expandable UPW Models:
 - Manual UPW model selection;
 - Automatic UPW switch based on impurity concentration;
- Multiple wafer rinse tanks;
- Multiple impurity species;
- Implementation of process control algorithm:
 - Tank water level control:
 - water level too low → close outlet stream
 - water level too high → close inlet stream, open exhaust
 - Impurity concentration control:
 - high impurity concentration in rinse tank: $C > C^*$ → stop wafer clean, stop water recycling, refill tank with clean water

Normal Operation

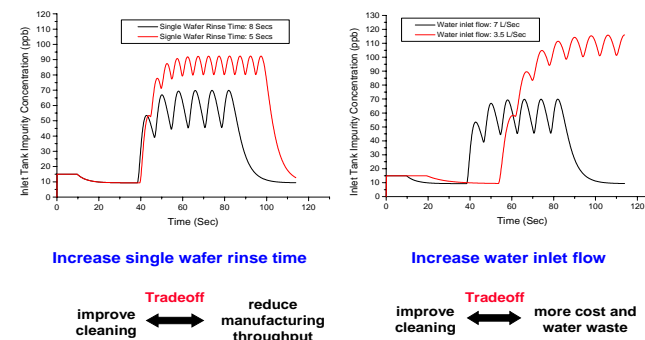


Transient Response & Control

Upset: sudden impurity increase in wafer rinse tank
 Triggers control response: when $C > C^*$ (Maximum allowed concentration), stop wafer rinse and stop water recycling



Tradeoff Analysis



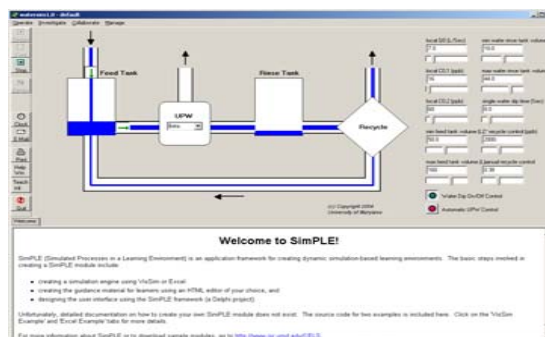
WaterSim 4.0 Development

- WaterSim 3.0, a physically-based dynamic simulator on water recycling process integrated with advanced learning platform (SimPLE), has been developed;
- The new version of dynamic simulator on water recycling has better structural organization, more robust control algorithm and better expansion capability;
- WaterSim 4.0, which uses the new simulator version, is more powerful and flexible, and will be available for use and partnering:

- Engineering
 - Significantly enhanced analytical and design capability
 - Interchangeable UPW components
 - Multiple rinse tanks
 - Transient/upset analysis
 - Development of optimized and robust sensor/control systems and algorithms
- Education
 - WaterSim 3.0 has been used in UA classes

Watersim 4.0 Development

WaterSim 4.0 User Interface



Conclusion

- Complete rebuild of a physically-based dynamic simulation model for water recycling process to optimize model design and versatility
 - Interchangeable components, flexible control algorithms, multi-component impurity streams, reusable model elements, distributed rinse tanks,...
- Dynamic simulation reveals essential behavior of water recycling process:
 - Simulation can be used as virtual experiment to test new UPW modules, justify process changes and optimize control algorithm
 - Time-dependent and time-integrated behaviors of technology, manufacturing and ESH metrics generated from simulation can be used for integrated ESH assessment
- WaterSim 4.0, which is based on the new simulator, is more powerful and robust than previous version and can be used for both engineering and education purposes