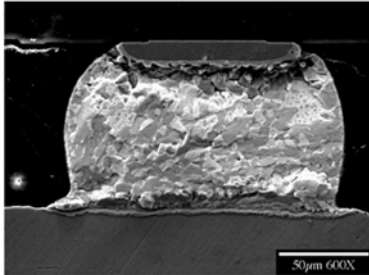


# Multi-Scale Modeling of Electromigration and Thermomigration in Nanoelectronics

## Background



Electromigration and Thermomigration induced failure of a flip-chip Solder Ball

### Evolution toward higher performance electronics

Next generation of solder joints and Cu interconnections will operate at much higher current density.

### Electromigration (EM) & Thermomigration (TM)

EM and TM not only lead reliability problems of Cu interconnections, but also enforce diffusivity and plastic behavior which cause damage and failure of solder joints.

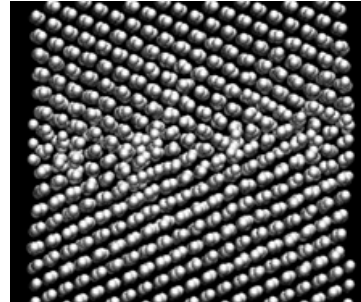
### Development of the next generation of miniaturized electronics

We need to understand and model these failure mechanisms based on fundamental physics rather than ad-hoc phenomenological models.

### Molecular Dynamics Simulation Software (LAMMPS)

Diffusivity is well explained on the molecular point of view. Molecular dynamics (MD) simulation has provided successful analysis results of molecular-level structure.

Molecular Dynamics Simulation by LAMMPS (Right) for Grain Boundary Diffusivity of Solder alloys

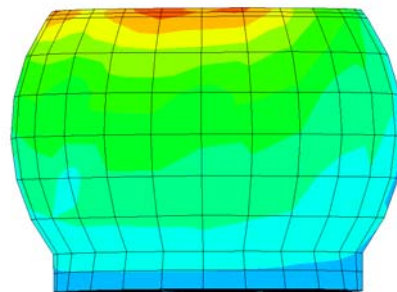


### Limitation of Separate Simulation Methods

In general, MD cannot be used for micro-scale length due to the restrictions on the number of atoms that can be simulated, along with the time scales which they can be simulated for. Moreover, atomistic-sized mesh of FE model for Continuum mechanics is theoretically unreasonable.

### Multi-scale Modeling

Coupling Molecular Dynamics with Continuum Mechanics takes place on Hand shake region. Developed bridging method on hand shake region will be used to efficiently connect MD with FE satisfying each boundary conditions.



### Finite Element Simulation Software (ABAQUS)

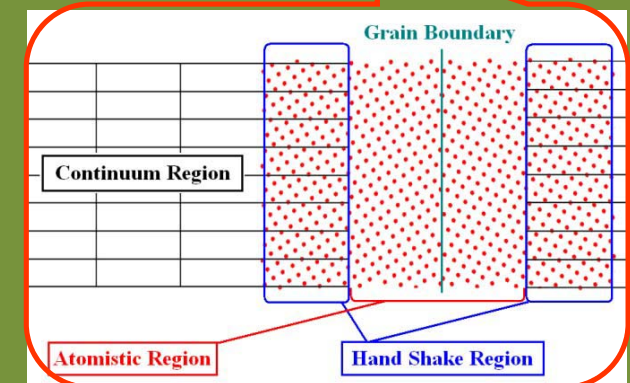
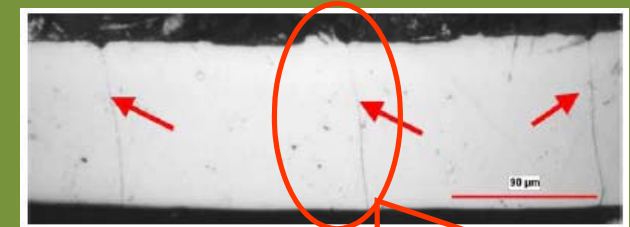
Electro-thermo-mechanical behavior has been successfully simulated by the finite element (FE) analysis on the continuum mechanics.

Finite Element Analysis Result by ABAQUS (Left) for the electro-thermo-mechanical behavior of Solder Ball

## Multi-Scale Modeling in Nanoelectronics

### Benefits of Multi-Scale Simulation

Coupling Molecular dynamics with Continuum mechanics allow to solve problems which are **more complicated** than ever with **greater accuracy** than ever before.



Bamboo-like Grain Boundary (above) and Multi-scale Modeling (Below) of a Thin File of Cu interconnection under Electromigration and Thermomigration

### Next Research

The next step of multi-scale modeling will be the experiments by Test Vehicle obtained from Semiconductor Research Center (SRC) member company to verify the developed multi-scale simulation method.