CEE

SHIKAZONO LAB.
[Solid Oxide Fuel Cell and Next Generation Heat Engines]

Collaborative Research Center for Energy Engineering
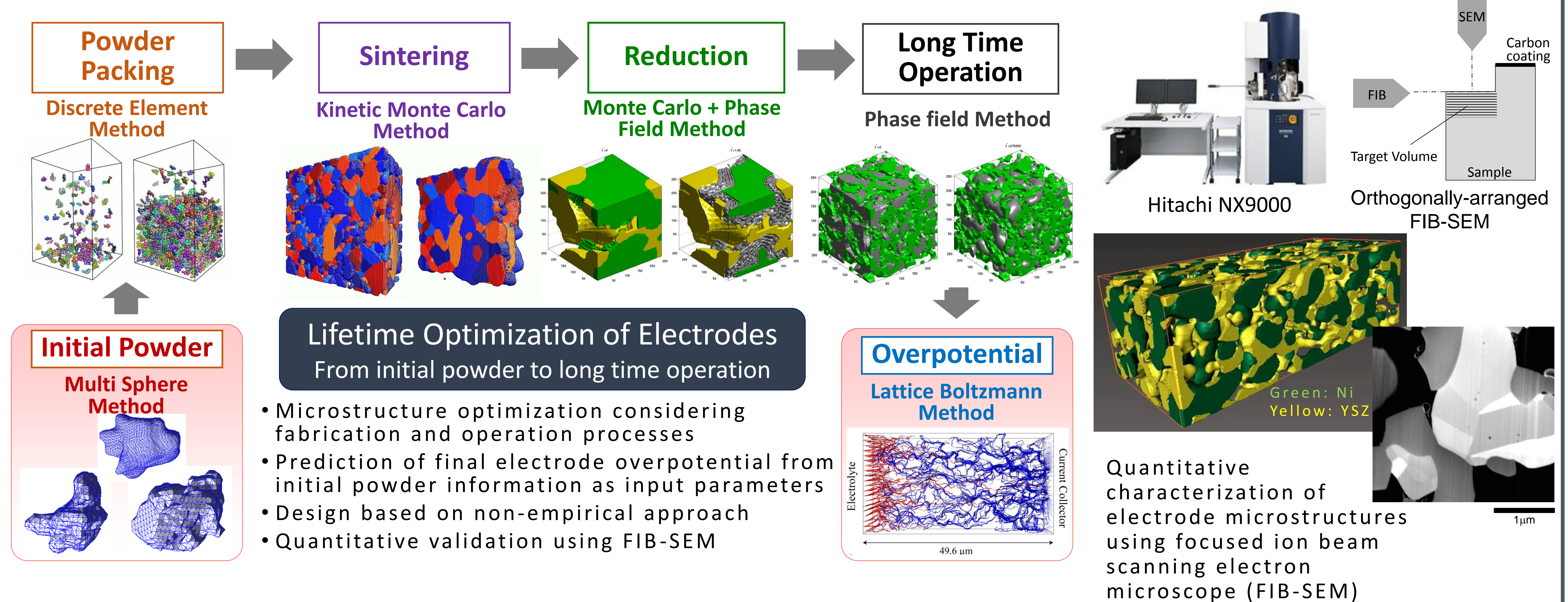
Thermal Energy Engineering

Department of Mechanical Engineering   http://www.feslab.iis.u-tokyo.ac.jp/

Prediction of Polarization Characteristics and Microstructures of Solid Oxide Fuel Cell Electrodes

In solid oxide fuel cell (SOFC) electrodes, it is widely known that their microstructures strongly affect polarization characteristics. Numerical simulation tools such as lattice Boltzmann, phase field, kinetic Monte Carlo and discrete element methods are developed to optimize whole lifetime characteristics of the electrodes from initial powder to long time operation. Three dimensional microstructures reconstructed by FIB-SEM plays inevitable role for model validation.

Powder Packing — Discrete Element Method

Sintering — Kinetic Monte Carlo Method

Reduction — Monte Carlo + Phase Field Method

Long Time Operation — Phase field Method

Hitachi NX9000

Orthogonally-arranged FIB-SEM

Initial Powder — Multi Sphere Method

Lifetime Optimization of Electrodes
From initial powder to long time operation

• Microstructure optimization considering fabrication and operation processes
• Prediction of final electrode overpotential from initial powder information as input parameters
• Design based on non-empirical approach
• Quantitative validation using FIB-SEM

Overpotential — Lattice Boltzmann Method

Electrolyte / Current Collector — 49.6 μm

Green: Ni
Yellow: YSZ

Quantitative characterization of electrode microstructures using focused ion beam scanning electron microscope (FIB-SEM)

1μm

R&D for Next Generation Heat Engines

Efficient utilization of thermal energy will become even more important in the future. In order to reduce exergy loss from the heat processes, heat engines which operate at low temperatures and component technologies such as compact gas-liquid separators and compact heat exchangers are developed under collaboration with industry partners.

• Development of trilateral and oscillating steam cycles
• Large scale numerical simulation of two phase flows using super computers
• Development of component technologies: laminar heat transfer enhancement, compact gas-liquid separators, compact finless heat exchanger, etc.
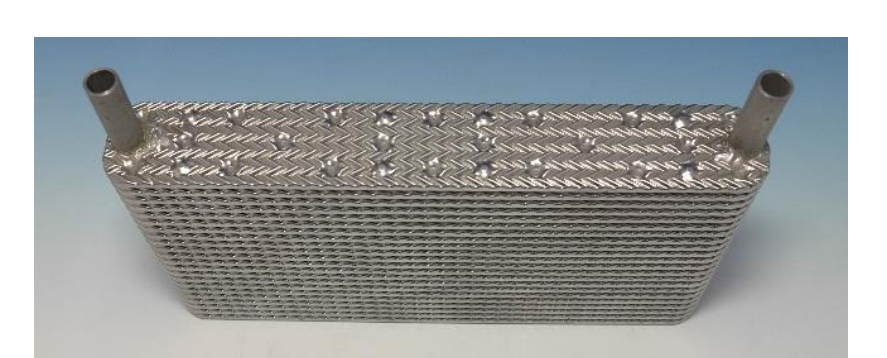

Two phase expander & demonstration unit for trilateral cycle
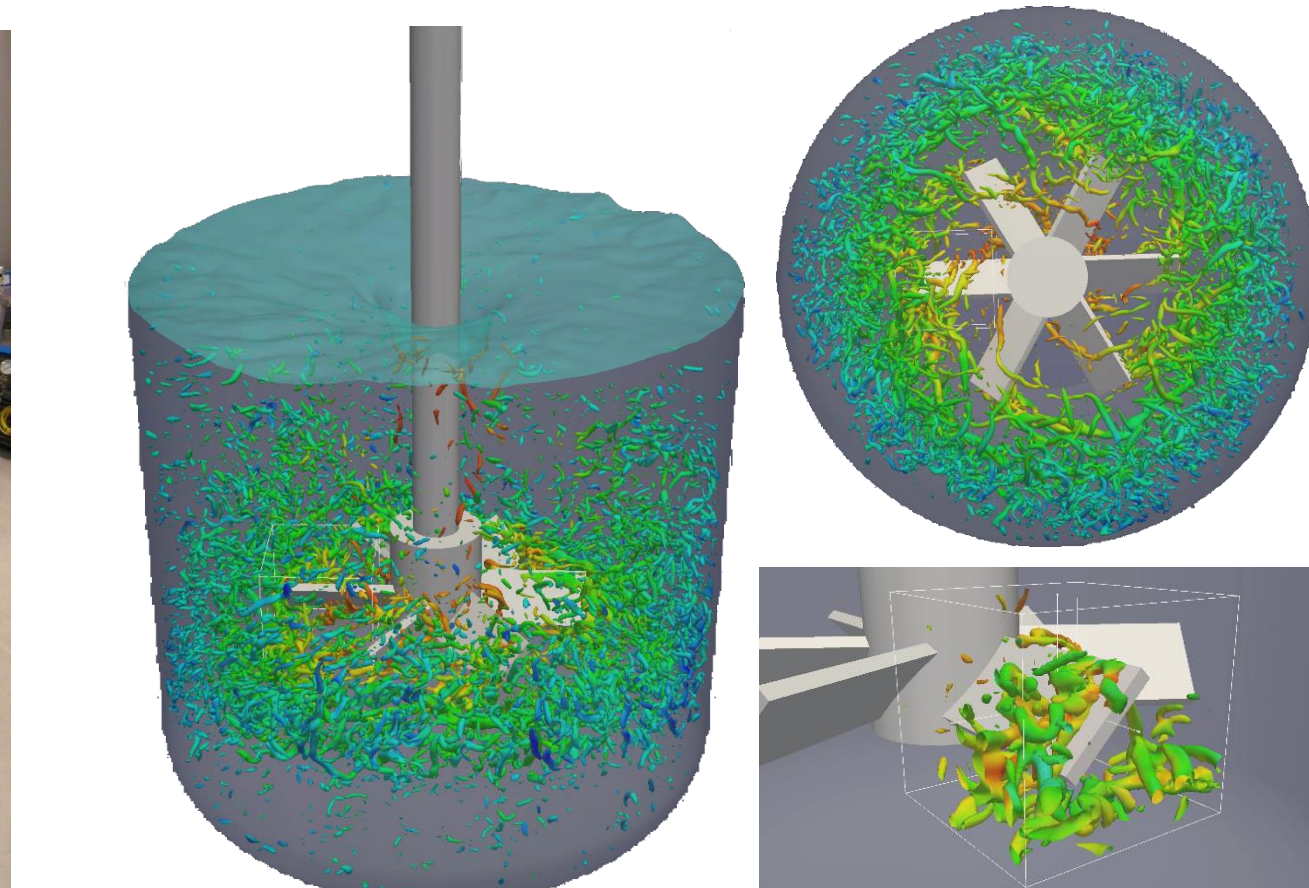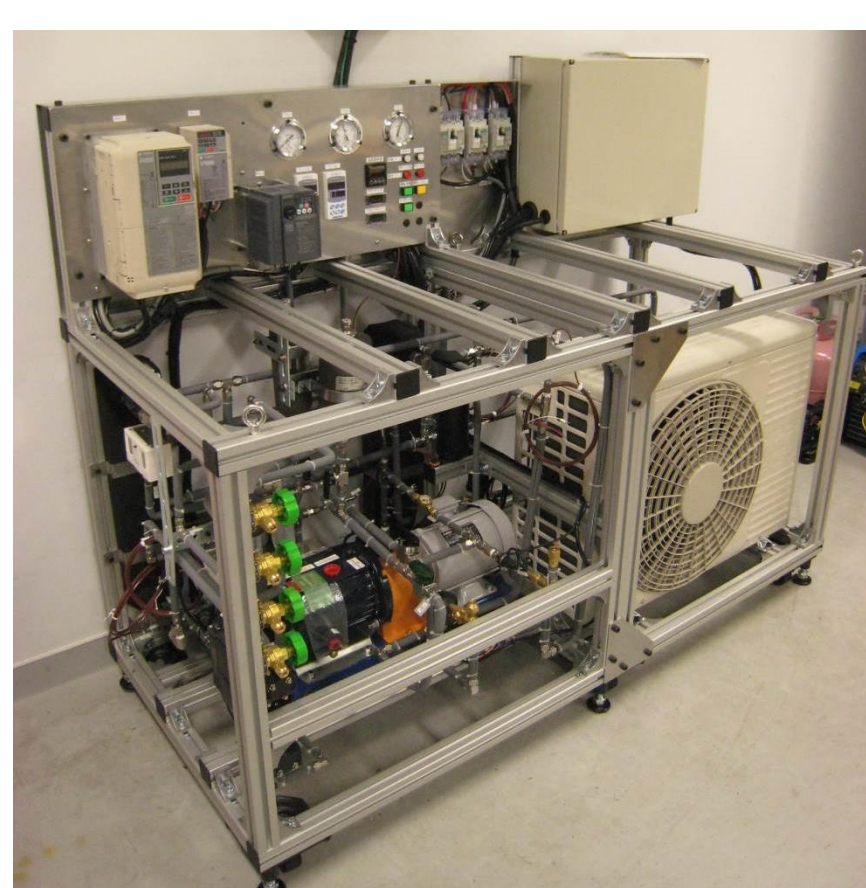
Two phase flow structure and gas-liquid interface shape in a mixing tank

Compact gas-liquid separator

Compact finless heat exchangers