SHIKAZONO LAB.

Solid Oxide Fuel Cell and Next Generation Heat Pumps and Heat Engines

Research Center for Sustainable Material Energy Integration

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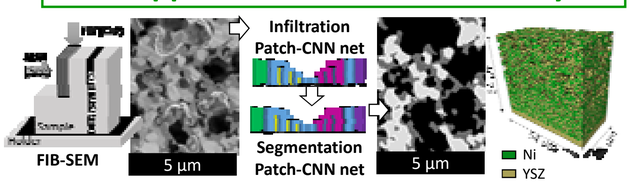
http://www.feslab.iis.u-tokyo.ac.jp/

Polarization Characteristics and Microstructures of Solid Oxide Fuel Cell Electrodes

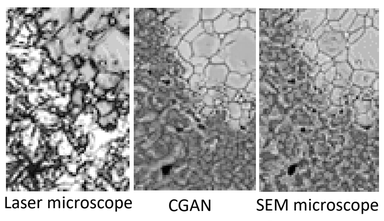
Electrode microstructures strongly affects the performance and reliability of solid oxide fuel cells (SOFCs). Machine learning, e.g. CNN, CGAN, UNIT, LSTM, etc., as well as large-scale numerical simulations such as lattice Boltzmann, phase field, kinetic Monte Carlo and discrete element methods are developed to optimize the whole lifetime characteristics of the electrodes from initial powder to long time operation. Three dimensional microstructures reconstruction by FIB-SEM and in operando observations play inevitable role for understanding the phenomena and model validation.

Machine learning in SOFC research

ML-supported microstructure analysis

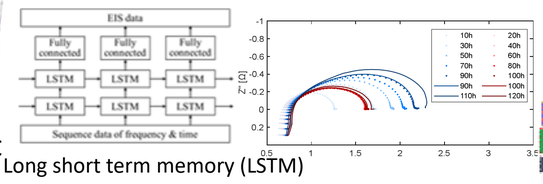


Microstructure segmentation



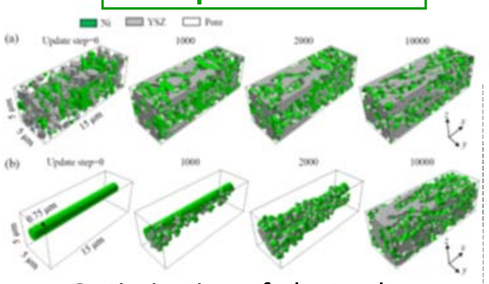
CGAN super resolution

Degradation prediction



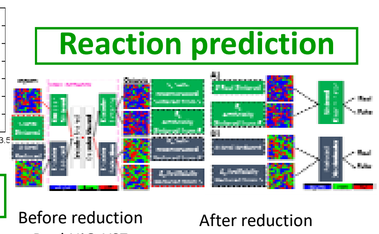
Long short term memory (LSTM)

Optimization

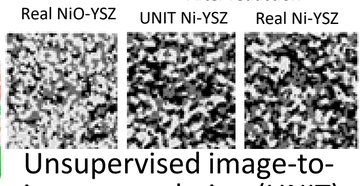


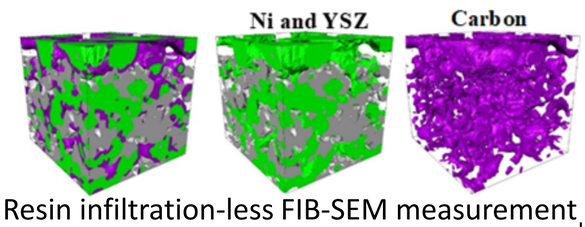
Optimization of electrode microstructure by adjoint method

Reaction prediction

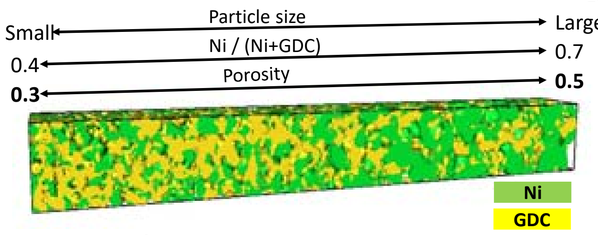


Unsupervised image-to-image translation (UNIT) prediction of NiO→Ni reduction.



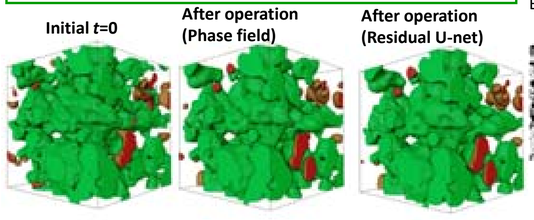


Resin infiltration-less FIB-SEM measurement

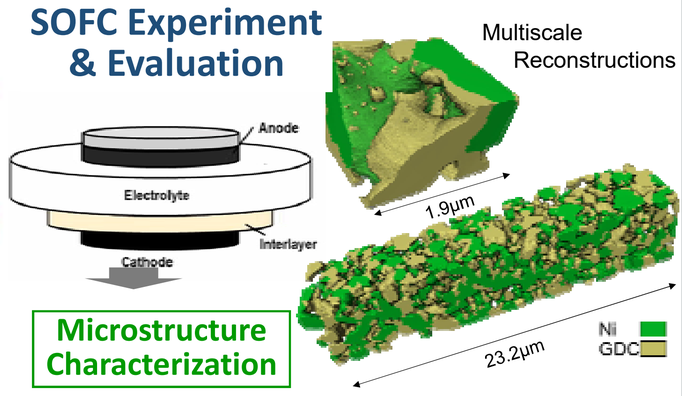


3D synthetic microstructure generation by CGAN

Long-time degradation prediction

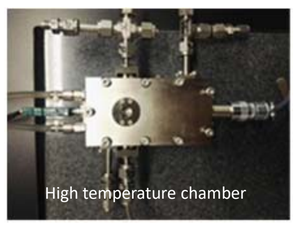


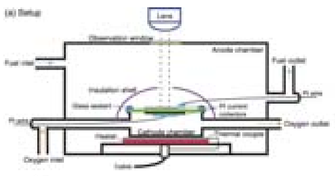
SOFC Experiment & Evaluation



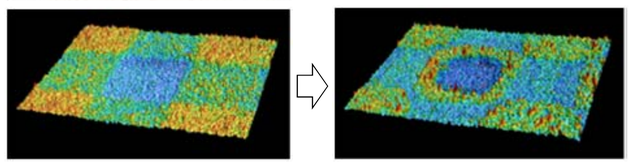
Microstructure Characterization

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





850℃, $V_{A\text{-}C}$=0.5 V
H_2:N_2:H_2O = 10:87:3 %, O_2 = 100%



Operando observation of patterned Ni-GDC electrodes under real operation.

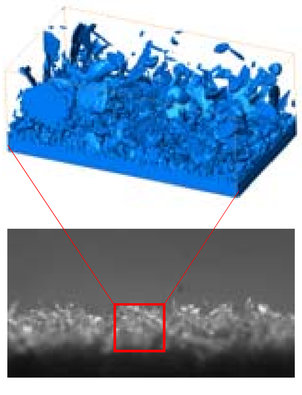
R&D on Heat Pumps & Heat Engines

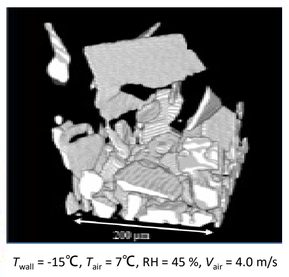
Efficient utilization of thermal energy will become even more important in the future energy systems. In order to reduce exergy loss, heat cycles which operate at small temperature difference, and component technologies such as efficient heat exchangers and gas-liquid separators are developed under collaboration with industry partners.

- Development of novel steam cycles (Trilateral & Lorenz cycles)
- 3D measurement of frost microstructure
- Heat exchangers and gas-liquid separators, etc.

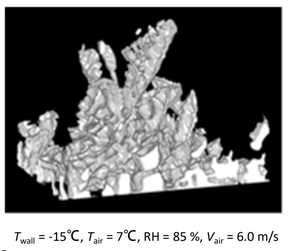
Vibration-free two phase expander

Corrosion-resistant aluminum latent heat recovery heat exchanger



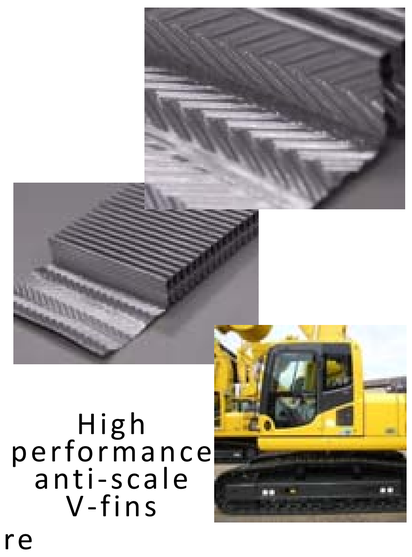


T_{wall} = -15℃, T_{air} = 7℃, RH = 45 %, V_{air} = 4.0 m/s

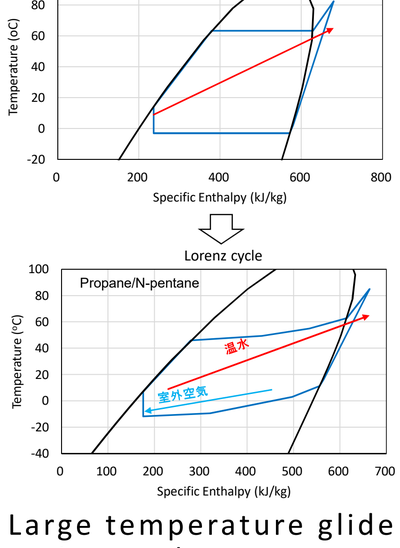


T_{wall} = -15℃, T_{air} = 7℃, RH = 85 %, V_{air} = 6.0 m/s

3D measurement of frost microstructure



High performance anti-scale V-fins



Large temperature glide Lorenz heat pump