Research topics for graduate students for 2024

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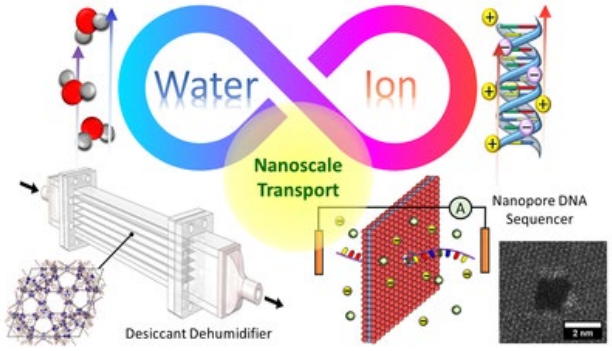
Department of Mechanical Engineering

Acceptable course(s)

- Master's Degree
- Doctoral Degree

Research Topics

In our group, we study *transport phenomena* in *individual nanopores* and *nanoporous media* to explore unidentified physical phenomena for novel engineering applications. Built upon the acquired knowledge, we develop prototypes of next generation energy or medical diagnosis devices. Currently, we are working on:



1. Development of solid-state nanopore DNA/RNA sequencing devices using two-dimensional materials.
Using solid-state nanopores drilled on suspended two-dimensional materials, we detect ionic current variations combined with machine learning tools to analyze single biomolecule structure up to atomic resolution [1].

2. Development of nanobubble emitters for electronics cooling and ultrasound imaging.
We employ the Joule heating occurring in a solid-state nanopore as an electric potential bias is applied to generate single nanopore bubbles. Using thermodynamic and fluid dynamic principles, we control the bubble size and release frequency in different pore diameter and applied voltage [2].

3. Development of next generation dehumidifiers using metal-organic frameworks (MOFs).
The high water compacity and stepwise adsorption characteristics of MOFs give rise to outstanding dehumidification performance over conventional desiccant materials. Currently, we study the dynamic behavior of water and heat of adsorption in MOFs for thermal management of desiccant-based air-conditioning systems [3].

Articles Related to Research Topics

[1] W.-L. Hsu et al., Theory of transport-induced-charge electroosmotic pumping toward alternating current resistive pulse sensing, *ACS sens.*, **3(11)**, 2320 (2018). [DOI: 10.1021/acssensors.8b00635]

[2] S. Paul et al., Single-bubble dynamics in nanopores: Transition between homogeneous and heterogeneous nucleation, *Phys. Rev. Res.*, **2**, 043400 (2020). [DOI: 10.1103/PhysRevResearch.2.043400]

[3] A. Agrawal et al., Molecular simulation study on the flexibility in the interpenetrated metal–organic framework LMOF201 using reactive force field, *J. Mater. Chem. A*, 8, 16385 (2022). [DOI: 10.1039/c9ta12065c]

Lab. Web page: http://www.thml.t.u-tokyo.ac.jp/en/