Energy devices, Fabrication

Investigation of structure formation mechanisms by materials and fluid interaction

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Abstract

Drying of slurry is a key technology for manufacturing products such as porous electrodes of fuel cells, electrolyzers and secondary batteries. However, trial and error approaches are the main methodology to develop fabrication processes of them from slurry at this moment, and scientific understanding is needed. This project aims to establish a methodology to investigate the slurry drying process by simultaneous measurements of fluid and dielectric behavior and to clarify the interactions of materials and fluid during slurry drying from a molecular scale to a macro scale. In this project, the developed methodology is applied to the fabrication process of fuel cell electrodes to clarify the mechanisms of porous structure formation.

Background & Results

The technique of dispersing powders and/or polymer materials in a liquid and forming thin films through coating and drying processes is widely used in actual manufacturing. However, the properties of this dispersion (slurry) vary significantly depending on the type and combination of the dispersed material and dispersing liquid. Furthermore, the slurry coating and drying processes involve complex flow and transport phenomena. Consequently, even when prepared under identical conditions, the resulting structures can vary significantly. Currently, manufacturing relies on trial-and-error adjustments to the materials and preparation conditions used. This implies that each time a new material is handled, forming the desired structure requires enormous time and effort. To address this, it is crucial to scientifically understand the flow and transport phenomena within the slurry coating and drying processes, along with the behavior of the internal materials, to control these phenomena. We are advancing our research to understand the phenomena in the fabrication processes from slurry using two techniques: white-light confocal microscopy and dielectric spectroscopy. White-light confocal microscopy revealed that even seemingly identical black liquids exhibit different surface morphologies and flow behaviors immediately after application, depending on their compositions. We also developed a technique to map height changes on the slurry surface with high temporal resolution. Dielectric spectroscopy provides information for understanding the dynamics of high-concentration slurries at the molecular scale. These two techniques can be used to measure simultaneously.

Significance of the research and Future perspective

Advancing this research will enable us to evaluate the flow and material behavior during the structure formation process through coating and drying of the slurry. We aim to elucidate the internal phenomena and structural formation mechanisms. Such research will enable the selection of materials and fabrication conditions based on a scientific understanding of the phenomena occurring during the manufacturing process. This is expected to lead to moving beyond trial-and-error in manufacturing from slurry, achieving the desired shapes and material distributions, and realizing unexplored functions by elucidating the relationship between shape and function.

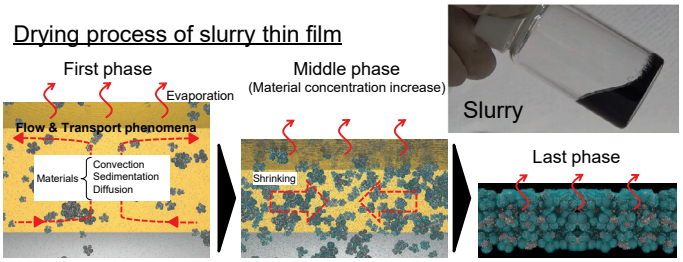

Fig. 1 Complex flow and structure formation during slurry drying

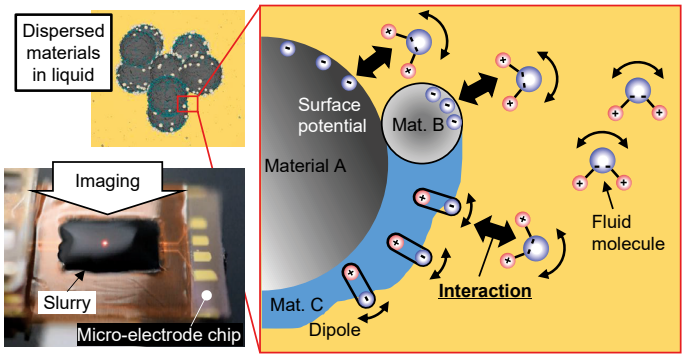

Fig. 2 In-situ measurement of slurry drying process

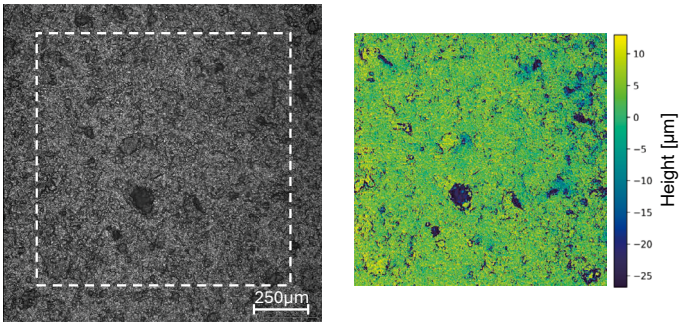

Fig. 3 Visualization of slurry surface

Patent

Treatise
Suzuki, Takahiro; Tsushima, Shohji. Fundamentals of fabrication from slurry and its applications to the formation of porous electrodes Journal of Smart Processing. 2023, 12(3), 131-140. (in Japanese) doi: 10.7791/jspmee.12.131
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Keyword slurry, in-situ measurement, complex flow and transport phenomena, hydrogen and fuel cells