Architectured Nanomembranes for In-Situ Energy Conversion Technologies

The objective of this nanomanufacturing concept definition study is to explore engineering concepts and analyze the technological and economic impacts of a novel type of architecture in nano-composite membranes. The nanoscale host-guest architecture contains oriented interfaces between nanotube/nanowire arrays perpendicular to the membrane layer. Membrane nanostructures determine the performance of a fuel cell, and also possibly, that of solar cells, thermal electric devices, and catalytic membrane reactors. These nanomembrane-based devices and process technologies provide significant energy, carbon, and economic benefits, which need to be evaluated to better define R&D paths for commercialization and market.

This project builds upon the proof-of-principle results of an Oak Ridge National Laboratory effort. Samples of uniquely architectured composite membranes, which contain parallel, cross-membrane nanochannel arrays filled with various designed composition and nanostructures, have been synthesized for the first time. Such oriented nanochannel array-based membranes could have superior performances in energy production or conversion processes such as fuel cells, solar cells, and catalytic membrane reactors. For example, impedance spectroscopy measurement data from a small-sized membrane specimen (~5 mm small dimension) have demonstrated a 4-5 order-of-magnitude enhancement in oxygen ionic conductivity when the oriented nanochannel architecture is incorporated with solid-state electrolytes.

For further industrial applications of such architectured platforms, there is a need to develop the engineering scale fabrication process that allows:

- Scale-up the dimension of such architectured nanomembranes,
- Production of them in large quantities, and
- Collection of performance data for engineering-scale nanomembranes.

This project is addressing the processing issues to enable the large-quantity production of such membranes in practical size, then evaluate them for specific energy applications such as solid oxide fuel cells. Furthermore, the overall technical and economic impacts of such nanomembrane platforms upon various energy technologies (catalytic membrane reactors for petrochemical oil conversion, proton-exchange membrane fuel cells, solar cells, thermoelectric devices, etc.) are being evaluated and life cycle analyses are being conducted.

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