Nanoscale Electrodeposition Process
for Manufacturing High-Selectivity Catalysts

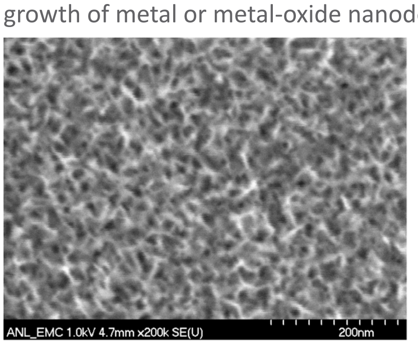
Inspired by the high selectivity of nature's enzymes (biomolecules with controlled size and shape, designed to catalyze specific chemical reactions), Argonne has developed a process for synthesizing nanoscale catalysts using a microscale electrodeposition system.

The Catalyst

The catalysts consist of catalytically active metal nanoparticles (e.g., copper) embedded in nanometer-sized cavities made of titanium dioxide. The high selectivity of the catalyst is achieved by finely tuning the size and shape of the nanocavities, specific for selected reactions, with the flexibility and control of of a micro-scale electrodeposition system.

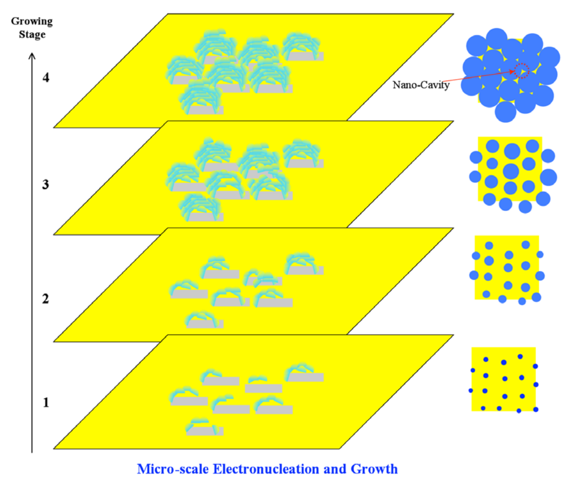
The Process

By using a non-aqueous electrolyte, such as an ionic liquid, a green solvent, and the pulse electrodeposition technique, we are exploring the development of a microelectrode array as a nanomanufacturing tool for a large-scale production system. Microelectrode pulse electrodeposition can provide very uniform electronucleation for the controlled growth of metal or metal-oxide nanodeposits.



Morphology of copper embedded under titanium oxide nanocavities (~10 nm)

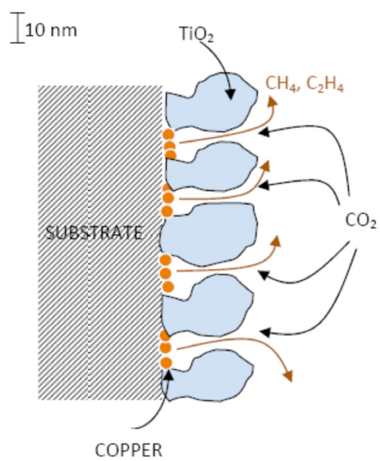
Nanocavities can be formed by the initial formation of many stable and uniformly distributed at-atoms on the substrate. Nanocavities can be formed by the simultaneous growth of these nucleates in later stages. The same situation can be applied to the formation of nanosized catalysts.



Nanocavity formation via electronucleation and growth

Applications

These catalysts will be applied to the electrochemical reduction of carbon dioxide (CO_2) for evaluating CO_2 utilization technologies in Argonne's CO_2 Sequestration Research Program.



Electrochemical CO_2 reductions

Such CO_2 utilization technology can be applied to the conversion of green house gases into hydrocarbons (e.g., methane or ethylene) for use as fuel or feedstocks by the chemical industry. These synthetic catalysts are used to enhance the selectivity of CO_2 for methane.

This process is very similar to what occurs in nature during the growth of plants and trees.

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