Turning lead into gold: Materials and nanostructures in electrochemical energy conversion

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We coat the pore walls of an anodic nanoporous template with either galvanic deposition or atomic layer deposition (ALD) to obtain structured electrode surfaces that provide the experimentalist with a well-defined, tunable geometry. Indeed, the platform consists of a hexagonally ordered array of metallic or oxidic nanotubes of cylindrical shape, embedded in an inert matrix. The diameter of the tubes can be defined between 20 and 300 nm and their length between 0.5 and 100 µm, approximately. We utilize them as a model system in which the electrode's specific surface area can be increased and its effect on the electrocatalytic current characterized systematically.

Diffusion-limited electrochemical transformations remain unaffected by changes in the length of the electrode's pores, whereas the steady-state galvanic current density observed for slow multielectron transformations increases linearly with the pore length. In particular, this approach enables us to reach a tenfold increase of the electrochemical water oxidation turnover at iron oxide surfaces. These results highlight a strategy for optimizing electrochemical energy transformation devices which could be generalized: the geometric tuning of catalytically mediocre but abundant and cost-effective material systems.