Single Molecule Catalytic Studies of Nanoscale Metal-Metal Junctions

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Abstract:
We aim to study catalysis at the interface of a heterogeneous nanoscale metal-metal junction, with the goal of determining what effect the junction has on activity compared with either metal, and also seeing how far the interface effect extends into either metal. The interface is made by electrodepositing striped gold and platinum rods into an alumina template. Alternatively, photolithography will be used to generate orthogonally intersecting gold and platinum stripes on a quartz surface. Catalytic reaction product formation will be detected and imaged using optical fluorescence sub-diffraction imaging.

Summary of Research:
In order to study the catalytic properties of two-domain, bimetallic nanostructures, we have been using the CNF to help fabricate a nanoscale gold-platinum interface in a couple of ways. The first way is based on alumina templated electrodeposition, in which a nanoporous alumina film is grown by anodizing a piece of aluminum. The alumina layer is removed and the pores are opened up from one end to the other by dissolving the thin barrier layer left at the bottom. An evaporator is used to put a thin silver film onto one side which serves as the working electrode for the electrodeposition of gold and then platinum. The particles are removed by selectively dissolving the alumina template and the silver layer. This method for making two-domain rods was pioneered by Thomas Mallouk and coworkers [1]. The second method to getting a nanoscale to microscale gold-platinum interface uses photolithography in which sub-micron width strips of gold and then platinum are evaporated onto a quartz surface in an orthogonally intersecting manner using lift-off lithography.

The bimetallic nanostructures are then coated in a porous silica shell to allow for optical detection of fluorescent product molecules using sub-diffraction fluorescence microscopy [2]. This technique allows us to capture a single catalytic turnover with spatial resolution of about 20 nm. We aim to quantify the catalytic rate in different domains within a single nanostructure, which will allow us to determine the effect on catalytic rate due to the presence of the junction.

References:

Figure 1: SEM of nanoporous alumina used as a template for electrodeposition.