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INVITED LECTURE

Electrochemical approaches to design materials for potential sensing and energy related applications

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It is the aim of our work to carry out fundamental studies on designing and synthesizing high surface area functionalized foam and ordered structures for their potential sensing and energy related applications. We combine electrochemical synthesis with structural studies on different length scales including transmission electron microscopy. Templates are directly grown by electrodeposition, either by hydrogen bubble formation or by utilizing of ordered structures formed by anodic electrochemical oxidation [1-3]. Recently we also demonstrate the synthesis of highly defected Al coatings by electrodeposition [4].

We employed an advanced approach to obtain open foam deposits of Ni and Ni alloys, by using electrodeposition at high current densities which promote hydrogen evolution and bubble templating (cf. fig.1 and fig.2) [1]. In the next step, the high surface area of such materials was functionalized by Pd utilizing a galvanic displacement reaction. Electrochemical testing of the obtained open foam deposits shows promising catalytic activity for hydrogen evolution in alkaline environments, as well as methanol and ethanol oxidation. In the case of fabrication of nanodendritic Ag, simultaneously grown with porous anodic aluminium oxide (cf. fig.3), we accomplished well anchored dendritic Ag nanostructures [2] of long-term stability [3].

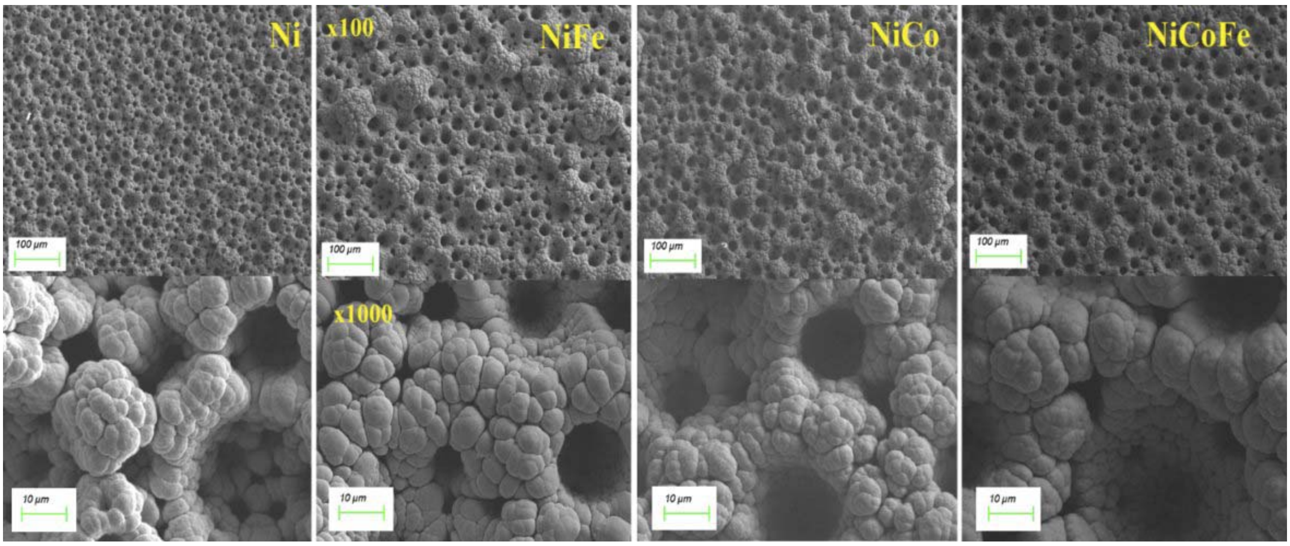

Figure 1. SEM images of high surface area foams of Ni and Ni alloys showing an open porous 'cauliflower-like' morphology, obtained by dynamic hydrogen template bubble deposition. The catalytic activity of NiCoFe foam is strongly enhanced for both, catholic reduction of oxygen and anodic evolution of oxygen showing a good reversibility. Therefore, this new material is promising as bifunctional catalyst in electrochemical energy conversion and storage devices [1].

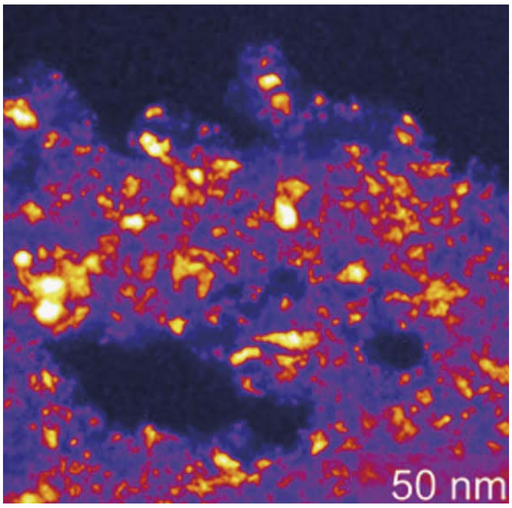

Figure 2. Open dendritic NiCoFe foam obtained by electrodeposition. TEM dark field image of the highly branched dendritic structure with crystallites smaller than 10 nm [1].

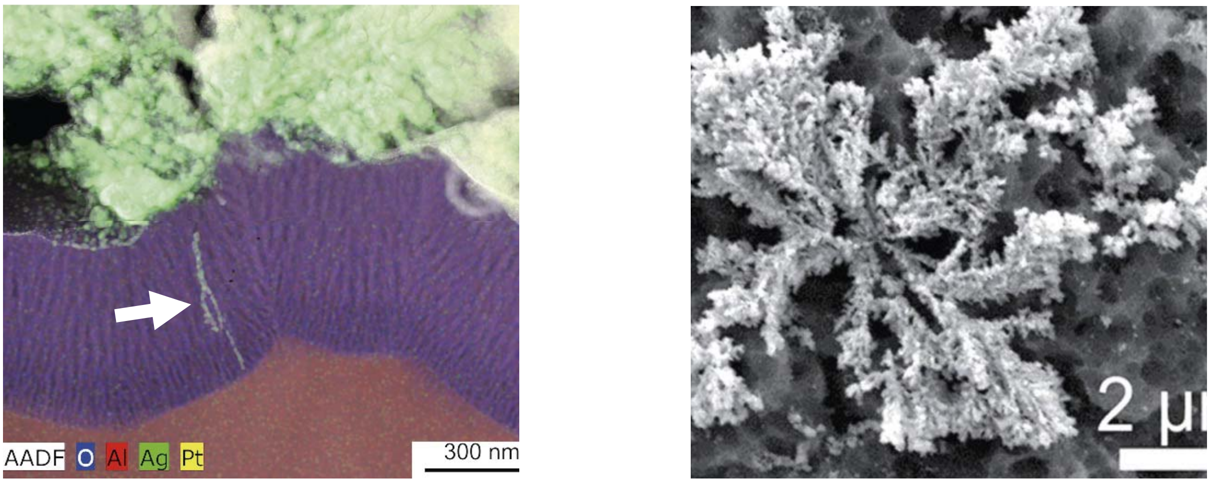

Figure 3. Aluminium oxide functionalized by Ag dendrites deposited at the anode during simultaneous electrochemical oxidation of Al. Ag is known for its high catalytic effectiveness in electrochemical oxygen reduction. (a) STEM image artificially coloured according to the results of EDX analysis including the elements O, Al, Ag and Pt. A striking feature is the channel (marked) in the Al_2O_3 layer showing it contains Ag and indicating it acts as root of the Ag dendrite above [2]. (b) SEM image of Ag dendrite revealing its fine branched structure and several Ag nanoparticles distributed on the porous Al_2O_3 surface [3].

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