

Nanostructured Nickel/Nickel Oxide Electrodes for Batteries and Fuel Cells

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Devices such as fuel cells, batteries and supercapacitors require high power electrodes for optimum performance. Such electrode materials must have high surfaces and a rapidly accessible pore structure so that reactant and product species may move in and out of the electrode with minimal resistance.

Lyotropic liquid crystalline phases of non-ionic surfactants have recently been used to template the electrodeposition of nanostructured metals within the confines of their aqueous phase¹. The resulting materials have been shown to possess a porosity composed of well ordered periodic channels of uniform diameter arranged on a hexagonal lattice as shown in Figure 1. Nickel is of interest as a relatively inexpensive electrode material for many applications. Cyclic voltammetry in alkaline solution has shown concomitantly high surface areas of approximately 500 m² cm⁻² calculated on the basis of redox reactions due to a few monolayers of oxide/hydroxide formed spontaneously in the aqueous medium. Not surprisingly, the diffusion of ions is relatively unhindered in the highly accessible pore structure and charge transfer is extremely rapid, as has been shown in the platinum analogue³.

In this work, the *in-situ* growth of more nickel hydroxide on the surface has produced electrode materials with a high redox capacity⁴. Applications in battery and supercapacitor technology are suggested by the large current densities observed in Figure 2 where the charge density remains constant at 80 mC cm⁻² regardless of the scan rate. Mesoporous NiOOH has been demonstrated to store lithium at low potentials by an electrochemically reversible reduction of nickel oxide to nickel metal and accompanying lithia formation (Figure 3).

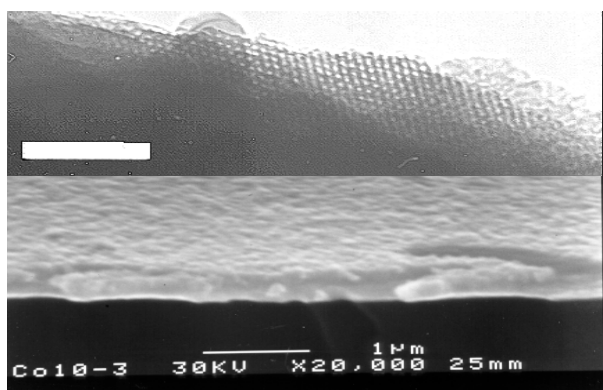


Figure 1. TEM of nanostructured cobalt deposited from the hexagonal phase of a Brij 56 based electrolyte².

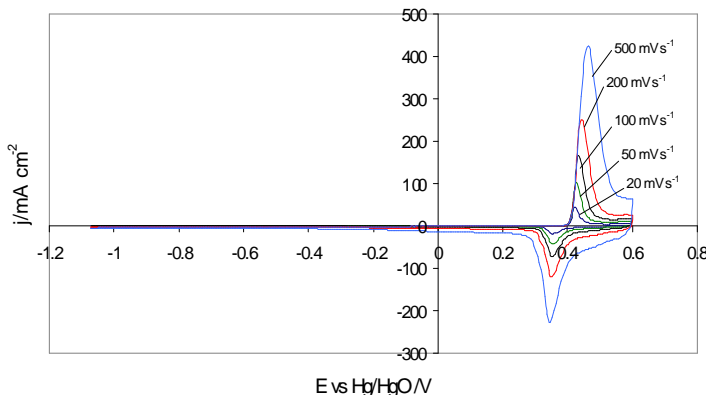


Figure 2. Cyclic voltammetry of nanostructured nickel in 6 M KOH at 25 °C shows extremely rapid charge transfer.

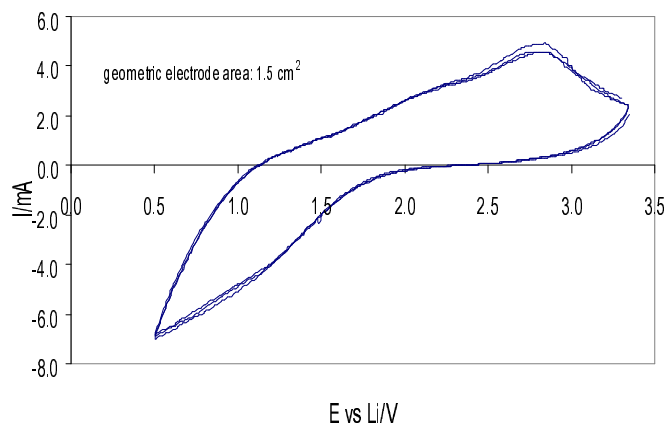


Figure 3 CV of Nanostructured NiOOH in 1 M F3CLiSO3/PC at 100 mV s⁻¹

An example of electrocatalysis by this novel electrode material is shown in Fig. 4. Applications in fuel cells will be presented at the meeting.

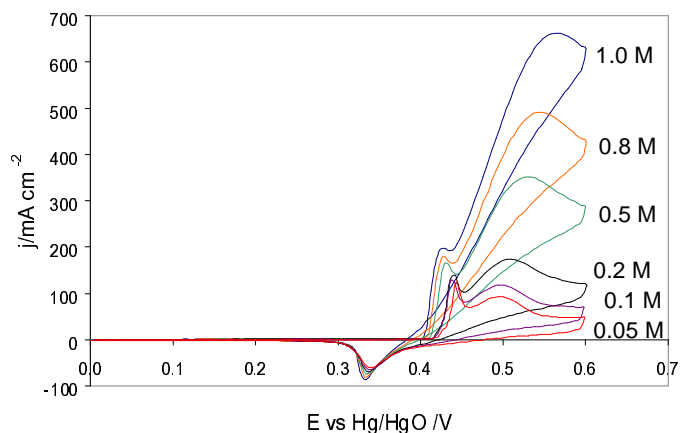


Figure 4 Ethanol oxidation on H₁ mesoporous Ni at 100 mV s⁻¹ in 6 M KOH

Conclusions

Nanostructured nickel/nickel oxide electrodes have been shown to cycle well in both aqueous and lithium electrolytes. The charge capacity and current density of these materials are presently limited only by the thickness of the original nickel plate.

References

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