Mesoporous Nickel/Nickel Oxide with Designed Structures for Supercapacitors

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Mesoporous nickel/nickel oxide composite electrodes having designed porous structures have been fabricated via the liquid crystal templating electrodeposition route. These electrodes possess continuous pores of uniform diameter with either hexagonal or bicontinuous cubic packing arrangements as illustrated in Figure 1. Our synthesis route allows pore-wall size and geometry to be tailored to a specific application by selection of the appropriate precursors and synthesis conditions. An all-mesoporous supercapacitor-battery hybrid based on Ni-MH battery chemistry has been constructed. This device, schematically represented in Figure 2, possesses the power density and cycle life of a supercapacitor but an energy density more closely resembling a battery. This is made possible by the mesoarchitecture of the electrode materials. Diffusion within the pore network is extremely rapid due to the non-tortuous electrolyte path as it is within the active material due to the small diffusion distances involved. This, in concert with the small size of the structures means that all of the active material in these high surface area materials is electrochemically addressable in very short times. Charge transfer has been shown to be limited only by the conductivity of the electrolyte (6 M KOH). Surfactant templated electrodes also have superior resistance to decrepitation over conventional electrodes. With cycling, the thickness of the $Ni(OH)_2$ active material (made by oxidation of mesoporous nickel) in the supercapacitor increases at the expense of the Ni current collector. This is in essence a self-compensating mechanism that resists capacity loss due to decrepitation. In fact, charge capacity has been shown to increase by 10 % over 15000 cycles.

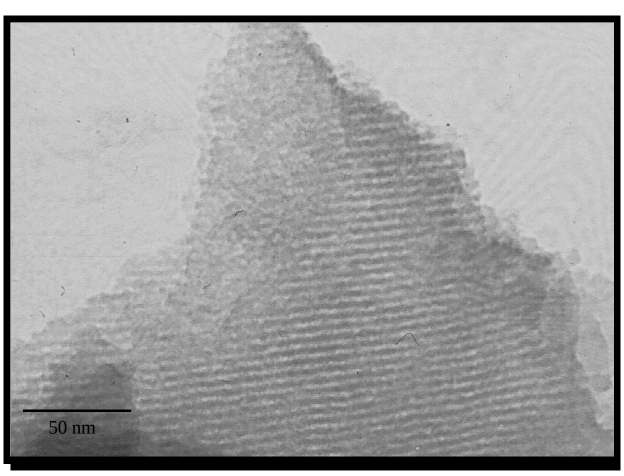

Figure 1 shows mesoporous nickel templated from the hexagonal phase of a Brij® 56 based liquid crystal.

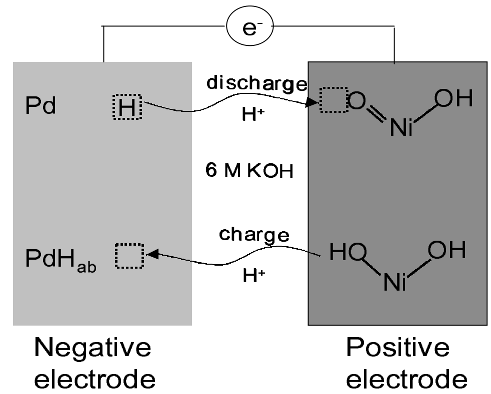

Figure 2 illustrates schematically the operation of the all-mesoporous supercapacitor which utilises Ni-MH battery chemistry.

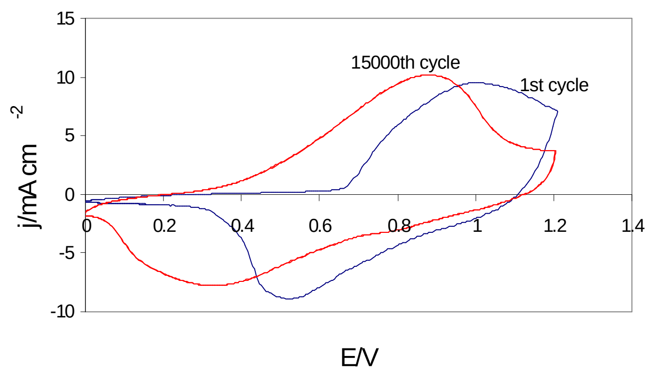

Figure 3 shows the effect of extended cycling of the supercapacitor at 500 mV s^{-1} after 15000 cycles using 6 M KOH as electrolyte.