FABRICATION AND PROPERTIES OF ELECTRODE ARRAY STRUCTURES AND MATERIALS

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Three-dimensional designs offer an attractive direction for miniaturizing batteries. In contrast to traditional cells with planar electrodes, the anodes and cathodes of these cells have active surface areas exposed in three directions. Such geometries offer certain advantages, such as a small areal footprint and short diffusion distances, and the ability to increase cell capacity without compromising energy density. These features are particularly important in the powering of MEMS devices where the available area for the power source is limited to millimeter dimensions. A key element in creating these new cell architectures is the fabrication of electrodes that possess three-dimensional configurations. Recently, we reported the use of micromachined silicon as a mold for fabricating electrode array structures [1]. The present paper addresses our progress in the fabrication of these electrode arrays and the development of the materials, vanadium oxide nanorolls (VONR) and single-wall carbon nanotubes (SWNT), used in these structures.

The silicon molds that serve as the basis for fabricating electrode arrays were produced by lithographic patterning, followed by either Deep Reactive Ion Etching, or by etching in KOH solution. These processes produce well-defined holes, which were then filled by the electrode material (SWNT or VONR) using colloidal powder processing methods [1]. The VONR was synthesized by a conventional method that involved an amine template and was subsequently ion-exchanged by sodium [2].

Figure 1 shows SEM micrographs of typical arrays based on SWNT (left) and VONR (right). The electrode arrays consist of 120 μm diameter circular rods composed of active material, carbon black, and PVDF. The SEM micrograph clearly demonstrates that the process was successful in producing a mechanically stable electrode array. Both types of arrays are electrochemically active and can be cycled, although at capacity levels less than that of traditional electrodes. One reason for the lower capacity is the use of the strongly basic solutions used to dissolve the silicon mold and release the electrode array. In this paper, we will present detailed characterization of the arrays and describe the interrelationship between array processing conditions and properties. In addition to electrochemical measurements, we will present our results on XRD, IR, elemental analysis and scanning probe microscopy that we have used to establish the chemical, structural and morphological properties of the electrode materials incorporated in the array structures. Electrical and electrochemical measurements on individual rods will also be described.

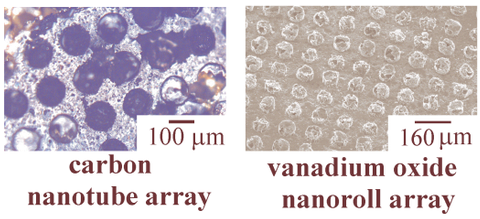

Figure 1. SEM micrographs of electrode arrays of single-wall carbon nanotube (left) and vanadium oxide nanorolls (right).

References

[1] G. Baure, G. G. Lee, C.J. Kim and B. Dunn, Micropower and Microdevices, Abstract # 696, Proceedings of Electrochemical Society Meeting, Saltlake city, Utah, Autumn, 2002, in press.
[2] S. Nordlinder, K. Edström and T. Gustafsson, Electrochem. Solid-State Lett., 4, A129 (2001).