C-MEMS/CNTs Electrode Arrays for 3D Microbatteries

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Advanced materials and novel battery designs are the two essential areas that will determine future advances in miniature batteries. In this work, we are incorporating carbon nanofibers (CNFs) and carbon nanotubes (CNTs) into carbon microelectromechanical systems (C-MEMS) to form arrays of electrodes for the formation of three-dimensional (3D) microbatteries.

Our C-MEMS technique is based on the pyrolysis of patterned photoresists [1-3]. This technique is used for the formation of carbon post with high aspect ratios as shown in Figure 1 (aspect ratio >10) [3]. We have demonstrated that Li ions can be charged and discharged in these carbon posts [3]. The obtained capacity is ~220 mAh g^{-1}, which is within the range of reversible capacities reported for coke.

Upon miniaturization of the active battery material in an array of posts, an increased Li capacity is important. This is very desirable so that besides increasing power density and decreasing battery charge/discharge rates, we also can maintain a high overall battery capacity. Since it has been shown that single-walled carbon nanotubes reversibly intercalate Li up to a rate of $Li_{2.7}C_6$ after applying an appropriate ball-milling treatment [4], we are now combining C-MEMS structures with CNTs and CNFs. The use of CNTs and CNFs in microbatteries has not been demonstrated. Further, the issue of the contact interface between these nanomaterials and current collectors has not been addressed.

We have started integrating CNFs into C-MEMS posts for achieving higher electrode surface areas and higher Li intercalation rates. As shown in Figure 2, CNFs is embedded at the surface of the C-MEMS post. Further, we have also been able to grow very high-density vertically-aligned multiwall carbon nanotubes (MWNTs) by thermal chemical vapor deposition [5]. As shown in Figure 3, these MWNTs can be patterned into arrays of microtowers. The application of these C-MEMS/CNTs and C-MEMS/CNFs electrode arrays for 3D Li ions microbatteries will be discussed in the conference.

References:

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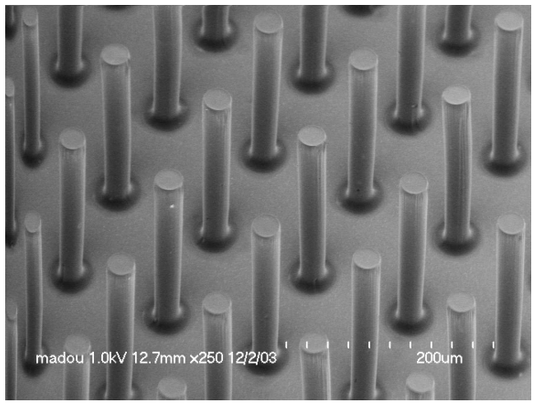

Figure 1. SEM image of carbon post arrays.

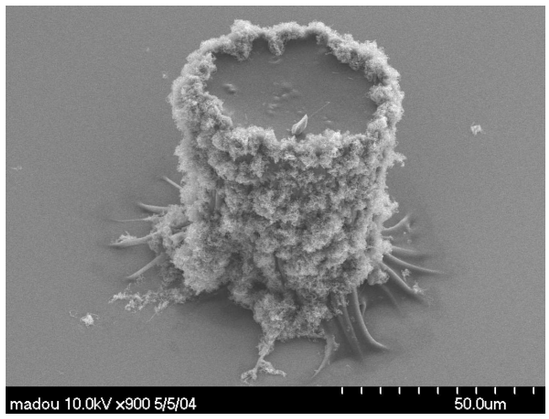

Figure 2. SEM image of a carbon post with carbon nanofibers grown around the sidewalls.

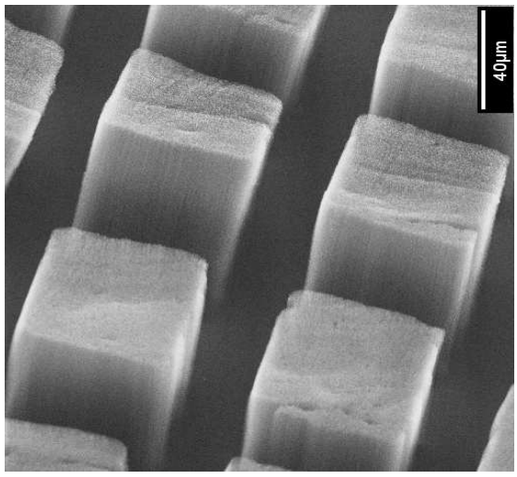

Figure 3. Regular arrays of MWNTs microtowers.