C-MEMS Technology for Li Ion Microbatteries

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Recently carbon-microelectromechanical systems (C-MEMS) has started to attract interest because of the many promising electrochemical applications such as in 3D microbatteries, DNA arrays and super capacitors. C-MEMS technology is based on the pyrolysis of patterned photoresists, such as SU-8 negative photoresist, in an oxygen free environment. [1,2] In recent work, we have demonstrated that Li can be charged/discharged in arrays of C-MEMS posts fabricated this way.[3] The obtained electrode capacity is about 220 mAh g^{-1}, which is within the range of reversible capacities reported for coke. Figure 1 shows typical high aspect ratio SU-8 photoresist post arrays. Figure 2 shows a schematic drawing of a switchable 3D microbattery and a typical SEM image of a two level C-MEMS array (i.e. electrodes and current collector are all made from carbon).

In the current contribution, we present our progress in the fabrication and characterization of completed batteries with posts of C-MEMS doped with Li for anodes and dodecylbenzenesulfonate-doped poly(pyrrole) (PPYDBS) for cathodes. We choose high molecular weight anion-doped PPY because of it's low specific weight, good chemical stability and good specific capacity, but most importantly because PPY can be electrochemically deposited on one set of carbon posts. The PPYDBS was deposited on the carbon post arrays by electrochemical polymerization of pyrrole from a sodium dodecylbenzenesulfonate (NaDBS) aqueous solution.[4] In Figure3 we shows typical PPYDBS post arrays with 5 micron of polymer deposited on the carbon posts. For thin film battery electrolyte we use poly (mehthylmethacrylate) (PMMA)-and poly (acrylonitrile) (PAN)-based gels applied over the posts of the C/PPy battery.

We will present a detailed electrochemical characterization of C-MEMS based anode and cathode materials and charge/discharge tests of completed batteries will be contrasted with a theoretical model of the C-MEMS battery. We will also discuss how to further improve battery performance by optimizing the geometry of electrolyte, anodes, cathodes and current collectors.

References:
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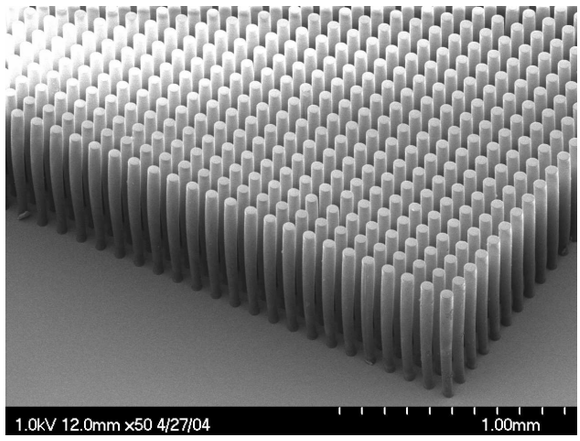

Figure 1. Typical SEM image of SU-8 photoresist post arrays.

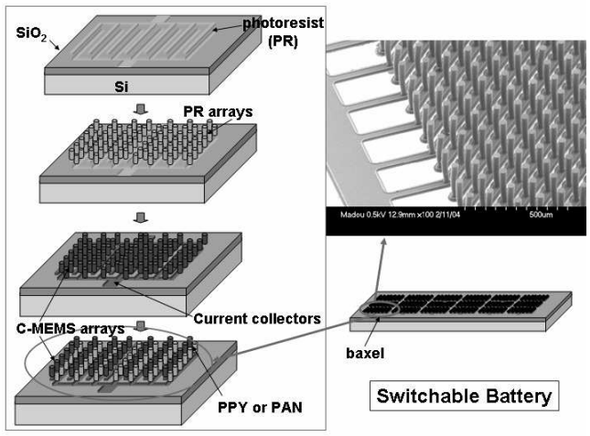

Figure 2. Schematic drawing of switchable 3D microbattery and typical SEM image of two level carbon arrays.

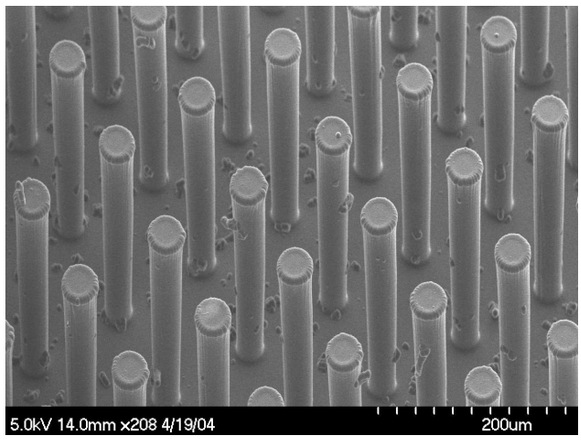

Figure 3. A typical SEM image of PPy deposited on carbon cores.