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Storing Energy on strained ZnO micro pillars for a Mechanical Battery

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The characterization of a ZnO micro pillars array has been carried out with the aim of predict the performance of a mechanical battery prototype based on the strain storage on micro-nano ZnO pillars. Our approach is based on compressing a micro pillars array grown vertically on a silicon substrate. ZnO has been chosen as a structural material due to its easy and low cost fabrication. We have grown ZnO arrays previously varying temperature, initial pH and concentration of the solutes for the hydrothermal process, in order to obtain well-aligned micro pillars arrays. The best samples were analyzed first with a statistical study to quantify the ZnO micro pillars physical dimensions, obtaining average densities, diameters and lengths of 0.28 micro pillars per square micron, 1.01 microns and 5.67 microns. Secondly, a mechanical study was done for a single micro pillar based on analytic calculations from the linear elastic theory and COMSOL FEM simulations. The buckling stress was taken as a first limit for the battery performance. Two boundary conditions, free-fixed and pinned-fixed were also considered as possible unstability behaviors. Finally, test samples with micro pillars arrays were compressed to characterize the strain levels and energy storage capabilities of the battery prototype. The general set-up for the mechanical characterization consists on an experimental homemade compressor integrated on a manual probe station, with two main functions: (a) to compress the micro pillars array with a controlled displacement, allowing different levels of compression and causing different levels of stress, and (b) the compressor structure has Si/Au electrodes for the application of a DC voltage sweep in the ZnO micro pillars arrays, in order to evaluate how does the IV curve reacts at different levels of compression. The resulting IV curves have a regular Schottky behavior at the Au/ZnO contact and show an increase of the slope when compression is increased. To model the IV curves the thermionic-emission was considered as the main conduction mechanism, since the experiments were done at room temperature and ZnO micro pillars were considered with a low doping impurity. The experimental and theoretical results agreed considerably.

Keywords: ZnO; pillars; hydrothermal; compression; battery; thermionic.