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Microelectronically fabricated $LiCoO_2/SiO_2$/Polysilicon cells

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The economic driving force for lower cost, higher performance and improved reliability has been applied successfully to Si CMOS technology. The enhanced development in electronics and optoelectronics technologies has increased the need for a rechargeable, integrated, all-solid-state thin-film battery compatible with microelectronics technology in terms of materials, processing and applications. Integrating distributed power sources with microelectronic devices will decrease conduction leaks, power losses and cross talking[1].

Our cells consist of $LiCoO_2$ and polysilicon electrodes and an electrolyte consisting of an ultra-thin layer of thermal Si-oxide. Solid-state battery electrolytes typically contain lithium and are 1-2 μm thick . An electrolyte of 0.5-2 μm thick porous SiO_2-15 at % P_2O_5 was used by Kushida et al in a Li-battery[2]. Our cells contain an electrolyte of 7-50 nm thick, silicon technology-compatible SiO_2.

The high-quality, ultra-thin oxide allows lithium ion transport and thereby compensates for the film's higher resistance compared to that of typical electrolytes. The cells were fabricated using microelectronics technology as described schematically in Figure 1. We have created highly planar Poly-Si/SiO_2 and $SiO_2/LiCoO_2$ interfaces, enabling the use of an ultra-thin electronically insulating electrolyte. In optimizing the structural properties for optimal battery characteristics, the polysilicon electrode is doped to improve electronic conductivity, and the SiO_2 is thermally grown from a 10-20 nm thick undoped polysilicon layer for better oxide quality. Figure 2 is a transmission electron microscope (TEM) image of a $LiCoO_2/SiO_2$/Poly-Si cell consisting of a 7nm thick lithium-free SiO_2 electrolyte thermally grown from a 20 nm undoped polysilicon layer. We were able to charge and discharge such cells proving that SiO_2 is an interesting candidate for a solid state electrolyte.

We have demonstrated the utilization of microelectronics processing in fabricating a $LiCoO_2/SiO_2$/poly-Si cell consisting of an ultra-thin SiO_2 layer as a novel lithium-free thin solid electrolyte.

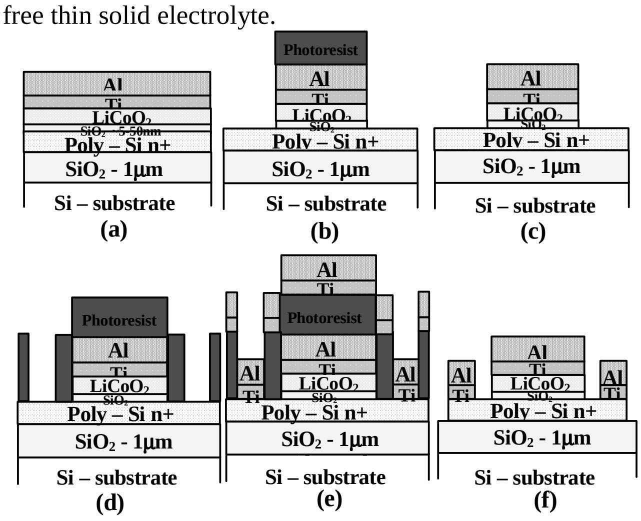

Figure 1: Fabrication of $LiCoO_2/SiO_2$/Poly-Si cells: (a) poly deposition and oxidation, $LiCoO_2$ and cathode contact deposition, (b) photolithography followed by etching to poly level (c) structure after etching, (d) photolithography to define anode contact (e) e-beam deposition of anode contact and lift-off (f) photolithography and poly etch for isolation of cells

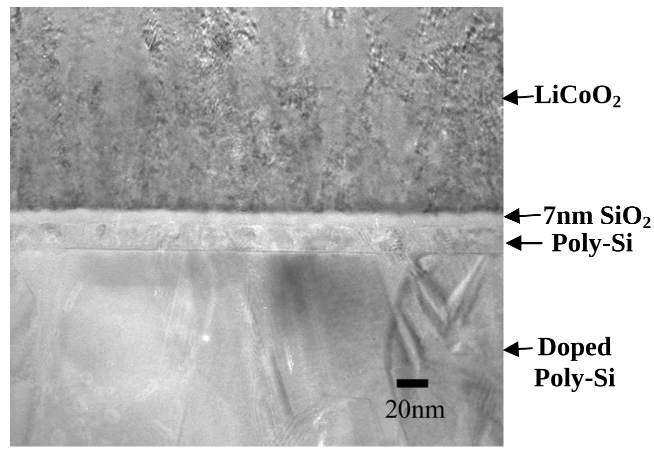

Figure 2: TEM picture showing a $LiCoO_2/SiO_2$/Poly-Si cell consists of a 7nm thick SiO_2 electrolyte

References:

1 M. Balkanski, Solar Energy Materials and Solar Cells **62,** 21 (2000).
2 K. Kushida, Kuriyama, K., and Nozaki, T., Applied Physics Letters **81,** 5066 (2002).