**Cyclibility dependence on microstructure of ruthenium oxide electrode for thin film micro-supercapacitors**

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In this work, we report cyclibility dependence of $RuO_2$/LiPON/$RuO_2$ thin film micro-supercapacitor on microstructure of the $RuO_2$ electrode film. Both bottom and top $RuO_2$ films were deposited over Pt current collector with different oxygen gas flow ratio [$O_2$/($O_2$+Ar)] of 10% and 30%, respectively. To investigate the microstructure of the $RuO_2$ films, which is grown at different oxygen flow ratio, both glancing angle x-ray diffraction (GXRD) and transmission electron microscope (TEM) analysis were employed. As shown Fig.1 and Fig.2, the film grown at 10% gas ratio demonstrate amorphous characteristics, while the film grown at 30% gas ration shows the polycrystalline characteristics. The results of GXRD are consistent with selected area diffraction (SAD) pattern shown in Fig.2.

Room temperature charge-discharge measurement based on symmetric $RuO_2$/LiPON/$RuO_2$ structure clearly demonstrates the cyclibility dependence on microstructure of $RuO_2$ electrode in Fig.3. Inset of Fig.3 exhibit plots of voltage vs. time for the TFSC containing the $RuO_2$ electrodes that were grown at a different oxygen flow ratio of 0.1 and 0.3, respectively. Although the sample grown at oxygen flow 0.1 exhibit higher initial discharge capacity than that grown at 0.3, the TFSC containing $RuO_2$ electrode grown at a oxygen flow ratio 0.3 show better cycling performance, compared to the sample grown at a flow 0.1. It is thought that the faster degradation of thin film micro-supercapacitor consisting of amorphous $RuO_2$ electrode is caused by many Li trapping sites, which is related with dangling bond in amorphous structures. In addition, the durability of crystalline $RuO_2$ film for Li intercalation compared to the amorphous sample plays important role to improve the cyclibility of the thin film supercapacitor having a crystalline $RuO_2$ electrode.

Using electrochemical and microstructural analysis, we correlate cyclibility of thin film micro supercapacitor with microstructure of $RuO_2$ electrode.

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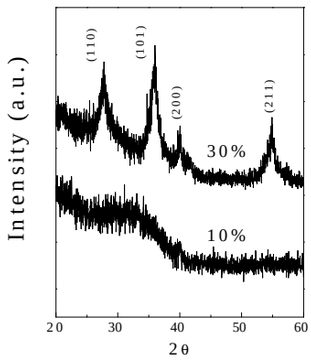


Figure 1. GXRD plots of the $RuO_2$ film grown at different oxygen gas ratio of 10% and 30%, respectively.

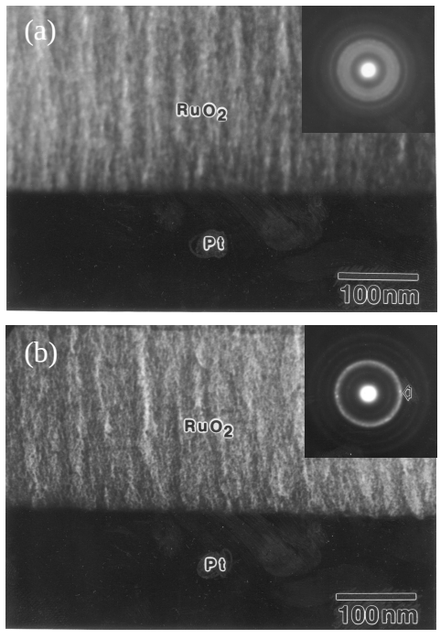


Figure 2. TEM image of the $RuO_2$ film grown at (a) 10% and 30% oxygen flow ratio with SAD pattern.

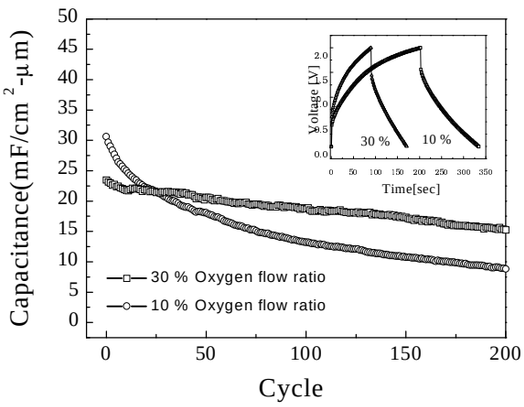


Figure 3. Room temperature charge-discharge profile as a function of cycle number (cycled between 0 and 2 V).