Supporting information

On chip, all solid-state and flexible micro-supercapacitors with high performance based on MnO$_x$/Au multilayers

Wenping Si,$^{ab}$ Chenglin Yan,$^a$* Yao Chen,$^a$ Steffen Oswald,$^c$ Luyang Han,$^a$ and Oliver G. Schmidt$^{abde}$

a Institute for Integrative Nanosciences, IFW Dresden, Helmholtzstrasse 20, Dresden, 01069 Germany. Email: c.yan@ifw-dresden.de
b Material Systems for Nanoelectronics, Chemnitz University of Technology, Reichenhainer Strasse 70, Chemnitz, 09107 Germany.
c Institute for Complex Materials, IFW Dresden, Helmholtzstrasse 20, Dresden, 01069 Germany.
d Center for Advancing Electronics Dresden, Dresden University of Technology, Germany.
e Merge Technologies for Multifunctional Lightweight Structures, Chemnitz University of Technology, Germany.
Figure. S1. (a) A low magnification, and (b) high magnification SEM images of MnO$_x$/Au multilayers on PET substrate, showing the particle size is around 15 nm.

Figure. S2. X-ray diffraction pattern of the as-prepared MnO$_x$ film, which is confirmed to be a mixture of crystalline MnO$_2$ and Mn$_3$O$_4$. 
Figure S3. X-ray photo-electron spectroscopy (XPS) characterization of bare MnO$_x$ film and MnO$_x$/Au film with 2 nm MnO$_x$ on top of gold to investigate the MnO$_x$/Au interface. Compared to bare MnO$_x$ film, MnO$_x$/Au film with 2 nm MnO$_x$ exhibits more surface OH oxygen in O 1s (the part circled by blue dashed ellipse), which is probably due to the gold influence at the interface.

Figure S4. (a) Cyclic voltammetry curves of the MnO$_x$/Au multilayer micro-supercapacitor measured in 1 M Li$_2$SO$_4$ at scan rates from 10 mV s$^{-1}$ to 1 V s$^{-1}$. (b) Comparison of volumetric capacitance for MnO$_x$/Au multilayers measured in aqueous (1 M Li$_2$SO$_4$) and gel (H$_2$SO$_4$/PVA) electrolyte at scan rates (10, 50, 100, 200, 500 and 1000 mV s$^{-1}$).
Figure S5. Comparison of the volumetric capacitance at scan rates (10, 50, 100, 200, 500 and 1000 mV s\(^{-1}\)) for MnO\(_x\)/Au multilayers with thickness of 50 nm, 100 nm, 200 nm. The 50 nm-multilayer is stacked in the order of MnO\(_x\)/Au/MnO\(_x\)/Au/MnO\(_x\), by three layers of 15 nm-MnO\(_x\) and two layers of 2.5 nm-Au. The 100 nm-multilayer is stacked in the same order, by three layers of 30 nm-MnO\(_x\) and two layers of 5 nm-Au. Considering thick layer may impede the electrochemical activity of MnO\(_x\), the 200 nm-multilayer is stacked by nine layers, with five layers of 36 nm-MnO\(_x\) and four layers of 5 nm-Au layers. As shown in this figure, the 50 nm-multilayer exhibits the highest volumetric capacitance.

Figure S6. Cyclic voltammetry curve of MnO\(_x\)/Au multilayer micro-supercapacitor measured at a scan rate of 1 V s\(^{-1}\) after the strain test.