Transition metal nitride thin films for electrochemical capacitor microdevices

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Micro-supercapacitors are attractive solutions for powering various devices such as sensors, Microelectromechanical systems or Radio Frequency Identification tags. These systems require high power density together with long cycle life [1]. Thus, a volumetric energy density ~ 100 times higher than that of conventional dielectric capacitors is required. Micro-supercapacitors can fulfil this requirement. They have been designed with various carbon based materials [1,2] but also with pseudocapacitive materials such as RuO_2, NiO or MnO_2 [3]. However, in this last case, aqueous based electrolytes are used. The main drawback is that the useful cell voltage is drastically limited, typically to less than 1V when assembling symmetrical devices. The same problem is raised for transition metal nitrides that have been recently proposed as high capacitance electrode materials for ECs [4,5], but with the same limitation as oxides since they are also operated in aqueous electrolytes.

To circumvent this limitation, asymmetric designs have been proposed, using two electrodes of different types operating in complementary electrochemical windows, thus enabling to enhance the cell voltage up to 2.2V in aqueous electrolytes [6]. Despite quite an abundant literature on the field [7] this concept has been poorly applied to thin film devices [8].

In this communication is reported a first application of nitride based thin film electrodes for microdevice fabrication. Vanadium nitride thin films was used as negative electrode. It exhibits pseudo-capacitive behavior in KOH electrolyte. NiO is a faradic oxide electrode used as positive. This asymmetric design leads to a microdevice (550 nm thick) which can be operated up to 1.8 V in aqueous based electrolyte (1M KOH).

Long term cycling ability (10,000 charge/discharge cycles) has been demonstrated with interesting energy (1.4 µWh.cm^{-2}) and power densities (47 mW.cm^{-2}). This new design open the way to potentially interesting nitride based asymmetric devices, since transition metal nitrides have demonstrated quite high capacitance values.

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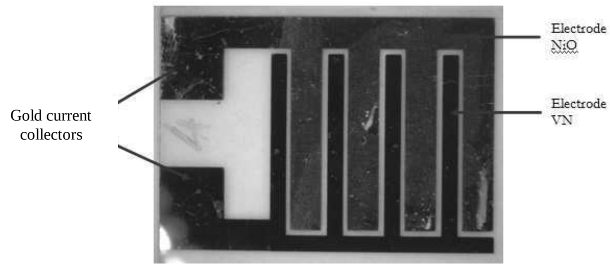

Figure 1: VN//1M KOH//NiO microdevice based on interdigitated electrodes.

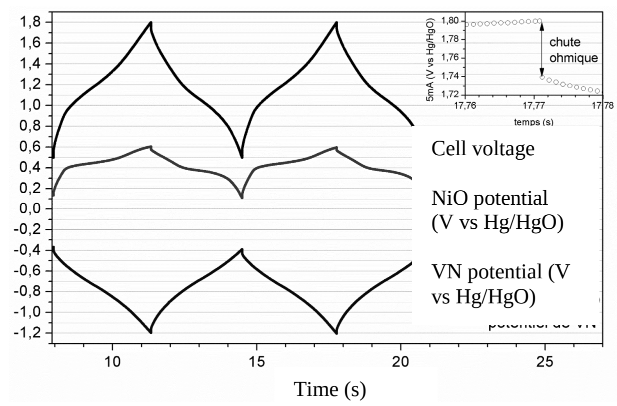

Figure 2: Galvanostatic charge/discharge (constant current I = 4 mA.cm-2) of asymmetric VN(-)//1M KOH//NiO(+) microdevice. Insert: detail of the ohmic drop upon shifting from charge to discharge.

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