Physico-Chemical Properties of V_2O_5 Thin Films Obtained by Atomic Layer Deposition (ALD)

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The vanadium pentoxide (V_2O_5) is a compound of high interest having in a wide range of applications. Among them is its use as a rechargeable cathodic material in lithium batteries.
There is growing interest in producing thin film lithium batteries for microelectronic applications. Vanadium pentoxide thin films have been deposited by several methods such as sol-gel, sputtering, chemical vapor deposition (CVD), electron-beam evaporation, thermal evaporation, flash evaporation and pulsed laser deposition (PLD). The investigation of other methods is an important issue since the properties of the films are depending on the deposition method.
In a previous paper (1), we have investigated the use of atomic layer deposition (ALD) to obtain vanadium pentoxide (V_2O_5) thin films. ALD technique (2) can be considered as a modification of the CVD and can be thus called "alternately pulsed CVD". Excellent coverage and uniformity of deposition are consequently obtained.
In the present study, vanadium oxide thin films were deposited on titanium substrate at 378K from vanadyl triisopropoxide, $VO(OC_3H_7)_3$ and water precursors. Since the as-deposited thin films were amorphous, they were annealed in air between 300 and 550°C. In terms of electrochemical properties, V_2O_5 thin films exhibit a good cyclability in the potential range 3.8 to 2.9 V vs. Li^+/Li. X-ray diffraction patterns have shown a strong preferential orientation of the V_2O_5 nanocrystallites along the substrate surface (Fig. 1) (3). Raman micro spectrometry has shown a good crystallization of the V_2O_5 thin films. Moreover, vibrational changes as lithium insertion proceeds were discussed in relation with structural data drawn from X-ray diffraction.
As a result, specific Raman fingerprints were evidenced during the formation of the successive α, ε, δ and γ $Li_xV_2O_5$ phases ($0 \leq x \leq 1.8$) related to the first three lithium insertions steps at 3.4, 3.2 and 2.8V vs Li/Li+ (4). The AFM study showed a good film stability before and after annealing by analyzing the film roughness. The root mean square (RMS) is around 20 nm for the V_2O_5 thin films. The electrical properties of V_2O_5 films were measured by the broadband dielectric spectroscopy (BDS) in the range of 10 to 10^{10}Hz at temperatures varying between 200 and 300 K. The spectra have been analyzed to obtain the electronic dc-conductivity *vs.* lithium content.

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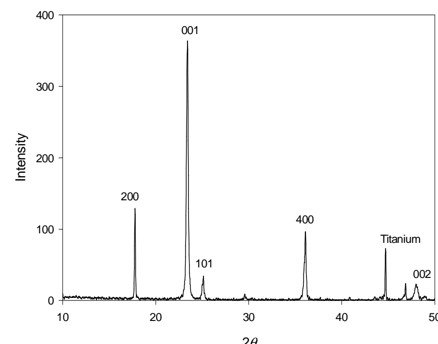

Fig.1 : XRD pattern of a V_2O_5 thin film (thickness= 800 nm) annealed at 770°K ($\lambda_{CoK\alpha1}$ = 1.7890Å)