Innovative approach to thin film sensor development

Ambiörn Wennberg, Iván Fernández Martínez
Nano4Energy SL, C/o ETSII-UPM Instituto de Fusión Nuclear, Spain
info@nano4energy.eu

Thin film technology has become a very important area of technology during the last decades. A large variety of product have sprung up from this technology development such as, flat screens, touchscreens, precision optics, solar cells and many different types of sensors and controls. The applications are many and many more to come.

Within the thin film technology there are also many different types of fabrication techniques such as laser deposition, chemical vapor deposition (CVD), physical vapor deposition (PVD) etc. Many of which are conducted in vacuum. One of the most extended and industrially used PVD methods is sputtering which is a plasma deposition method performed in vacuum. The main reason to this is its ability to deposit films in the square meter range with excellent thickness and composition uniformity combined with high deposition rates [1].

Deposition in vacuum provides high purity devices with a great deal of control of the composition, and thus the function of the device. However it does give some limitations concerning the types of materials that can be used. Metallic materials are generally fairly easy to use, pure or as metallurgically mixed deposition targets. Also mixing the metals with gas state materials are nowadays industrially implemented with a great deal of control, most often using so called reactive sputtering.

Reactive sputtering is using different kinds of sensors to monitor the actual state and deposition conditions at a real time basis and reactively adjust the parameters for the desired result. The main pioneers in this field are Gencoa Ltd based in Liverpool, UK.

The rapid development in the field however increases the demand for new specialized more complex mixes of materials also including solid or liquid state non-metallic materials, such as Sulfur, Selenium, Tellurium and various types of organic materials etc.. These materials have long been a challenge to introduce into the vacuum process in a controlled and cost efficient manner.

Nano4Energy has applied an innovative approach to this issue using pulse technology. By evaporating the desired material at a highly controlled temperature, thus controlled vapor pressure, then introducing the vapor through a pulsed valve, using a Pulsed Valve Cracker Effusion Cell [2], where the frequency and opening time can be controlled, the composition in the substrate is highly controllable. In addition to this a reactive feedback system based on plasma emission monitoring (P.E.M) has been developed and implemented, in collaboration with Gencoa Ltd. The technology enables to maintain the balance of metal and evaporated atoms at the optimum level for obtaining high deposition rates and control of the film stoichiometry. This is crucial for obtaining high efficiency devices, previously only achieved using gas state materials.

This demonstrated innovative approach not only increases controllability, thus improving process yields and reducing product cost, in the industrial scale process, it also provides a new degree of stoichiometric freedom for the development of sensors, controls and many other applications. Applications and devices that are currently under development using this technology are CIGS/CZTS solar cells, infrared sensors, Bragg mirrors and organic encapsulation of e.g. OLED technology.

Figures

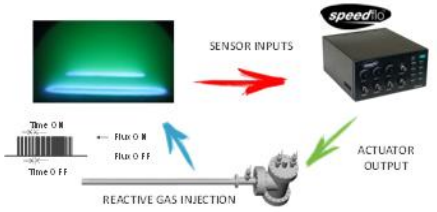

Figure 1: Schematic view of the Pulsed Valve Cracker function with the reactive feedback control system [3]

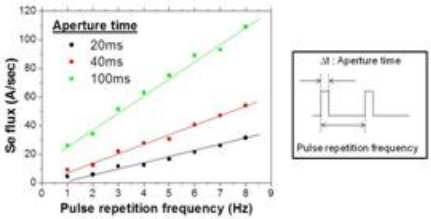

Figure 2: Left: Example of Se flux measured with a Quartz Microbalance as a function of the valve aperture repetition frequency and for different aperture times (time on). The flux is linearly proportional to repetition frequency, and dependent on the valve aperture time. An active control in the valve aperture parameters allows an excellent control of the flux. Right: Schematic of the Cracker Valve controls pulses of atomic vapor. By adjusting the time on (valve aperture time) at a particular repetition frequency of pulse different average flow can be injected into the vacuum deposition system.

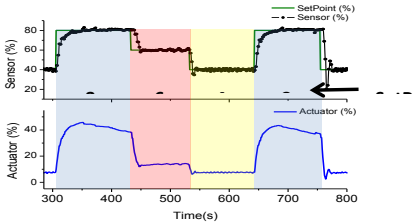

Figure 2: (Example of the rapid response when changing the set-point to vary the stoichiometry when using reactive feedback control and the pulsed valve cracker. The new stoichiometry is stabilized within seconds from the change in set-point.

References

[1] V. Bellido-González, B. Daniel, J. Counsell and D. Monaghan, Thin Solid Films 502, 34 (2006).
[2]Nano4Energy SL, C/o ETSII-UPM, José Gutiérrez Abascal 2, E-28006 Madrid, Spain. www.nano4energy.eu
[3] V. Bellido-González and I. Fernández-Martínez: GB Patent 1307097.4 (2013)