Room Temperature Sputtered Ta_2O_5 for Solid State Biossensors

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Since the enzyme modified electrode was invented by Clark in 1962 this area of research has been ever growing. Biosensors have application in many areas of interest from agriculture to industrial control, pharmaceutical to health care. Consequently much effort is put into new and improved materials for device optimization and sensitivity enhancement.

Ion sensitive field effect transistors (ISFETs) based biosensors have a fast response and are suitable for miniaturization, since the signal-to-noise ratio is independent of the device area. It is also possible to integrate several ISFET sensors to allow the simultaneous measurement of various parameters by coating each gate dielectric with a specific biological agent.

High-k dielectrics that are used as the gate oxide, such as Ta_2O_5, show sensitivity to pH so the optimization of this sensitive layer is crucial.

An advantageous technique for oxide thin films deposition is radiofrequency (rf) magnetron sputtering because it permits good quality films to be obtained at room temperature and the use of low cost disposable substrates such as plastic and even paper.

We present a study of Ta_2O_5 thin films deposition conditions and their influence on pH sensitivity. The films were produced by varying some deposition parameters, such as argon and oxygen partial pressure ratio and deposition pressure. The influence of post-production treatments such as annealing temperature and plasma surface treatments with argon and oxygen, performed under several conditions, were also studied in order to assess their contribution to pH sensitivity. The films were deposited on p-doped Si/SiO_2 substrates in an electrolyte-insulator-semiconductor (EIS) capacitive structure that was used to evaluate the sensors' response to pH (Fig.1). EIS devices mimic the gate structure of the ISFET and have the advantage of being easier to fabricate. Capacitance measurements were performed in a standard three electrode configuration (Fig.2).

An enzyme modified sensor was successfully constructed by adsorptively immobilizing penicillinase onto the surface of the Ta_2O_5 film that yielded the optimal pH sensitivity. The underlying pH sensor detects the variation in H^+ concentration resulting from the catalyzed hydrolysis of penicillin G by penicillinase, which is dependent on the penicillin concentration in the solution.

The application of the studied sensitive Ta_2O_5 films to ISFET biosensor structures was also studied and will be discussed.

References

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Figures

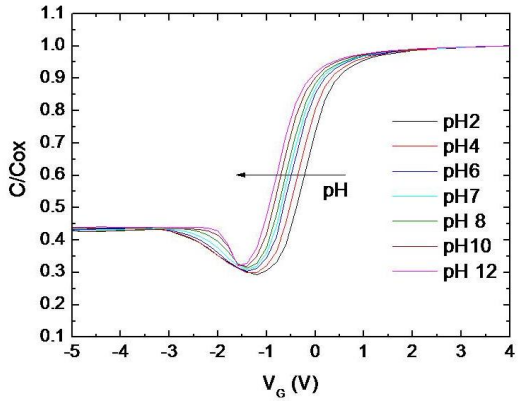

Fig. 1 – EIS device's capacitance *vs* voltage characteristics variation due to pH.

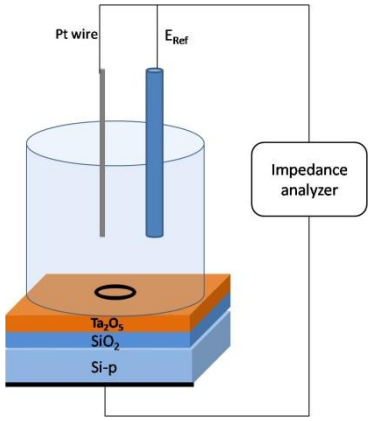

Fig. 2 – Experimental set-up used for EIS structure capacitance measurements