Penicillin Detection by Means of Silicon-Based Field-Effect Structures

Arshak Poghossian¹, Marion Thust¹, Peter Schroth¹, Alfred Steffen¹, Hans Lüth¹ and Michael J. Schöning¹,²*

¹Institute of Thin Film and Ion Technology, Research Centre Jülich GmbH, D–52425 Jülich, Germany
²University of Applied Sciences Aachen, Girsterweg 1, D–52428 Jülich, Germany

(Received July 24, 2000; accepted April 12, 2001)

Key words: penicillin, capacitive EIS sensor, cross-sensitivity, EnFET, low detection limit

Two types of semiconductor-based field-effect biosensors, i.e., a capacitive electrolyte-isolator-semiconductor (EIS) sensor and an enzyme field-effect transistor (EnFET) with different pH-sensitive transducer materials (Si₃N₄ and Ta₂O₅) and with different enzyme immobilisation methods (heterobifunctional cross-linking and physical adsorption) are investigated for penicillin detection. Capacitive EIS sensors with diffusion barriers are suitable for the detection of different kinds of penicillin: Penicillin G, ampicillin and amoxicillin. Compared to the conventional methods of measurement in penicillin solutions, the introduction of a diffusion barrier in combination with a suitable working buffer improves the detectable amount of penicillin to about 0.05 µg. Here, only 10 µl of the analyte is needed for a single penicillin measurement. For a penicillin FET with adsorptively immobilised penicillinase, excellent working characteristics, namely, high penicillin sensitivity (120±10 mV/mM in the linear concentration range of 0.05–1 mM), low hysteresis (< 4 mV), low detection limit of 10 µM and long lifetime (more than 5 months) were achieved by choosing Ta₂O₅ as a pH-sensitive transducer material, and a low capacity polymix buffer.