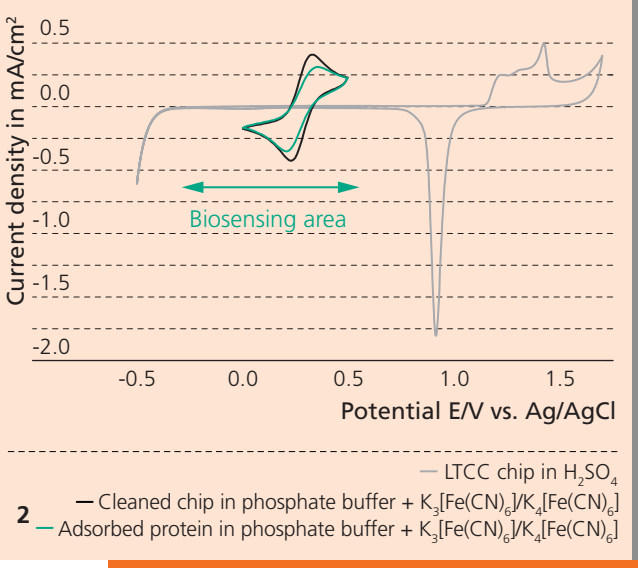
1



2

SENSORS: CERAMIC-BASED MICROCHIPS FOR BIOANALYTICS

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Fraunhofer IKTS develops concepts for ceramic-based biosensors as well as the required materials and processes for manufacturing and characterization of them. Because of their excellent stability and reliability, high-performance ceramics are taking on an increasingly important role in electronics. Ceramic microelectromechanical systems (MEMS) in the medical sector, specific channel structures for the complex handling of fluids and gases, even under extreme conditions, and integrated functional ceramic microelements are characterized by higher sensitivity and multiselectivity. Especially in biosensors, ceramic materials offer the unique properties of long-term stability, biocompatibility, and the combination of electrical and insulating properties.

Immobilization of biomolecules represents a substantial challenge for the development of biosensors because stability, functionality, and specificity of the biocomponents should not be affected. In an initial step, IKTS scientists focus on the long-term stability of the physicochemical components under cyclic loading and the general possibility of biochemical functionalization. Different substrate materials for low-temperature co-fired ceramics (LTCC) and gold pastes are selected for the chip production to ensure optimal conditions for biosensor applications; this is a prerequisite for ceramic multilayer technology, which potentially allows for 3D structuring and system integration and at the same time a hermetic barrier as well as economical large-scale manufacturing. Use of these chips in electrochemical biosensors places special demands on the surface quality of the gold electrodes and hence the ceramic substrates. For this reason, the surface roughness was optimized and could be reduced by 30 to 50 %, depending on the given LTCC. In tests in acid media under cyclic conditions (cyclic voltammetry), suitable combinations ensuring good adhesion and long-term stability of the gold contacts as well as minimal dissolution and degradation were identified. Except for capacitive currents, no reaction is visible in a wide electrochemical window bounded by redox peaks. Within these stationary regions, even small signals corresponding to biorecognition on the functionalized sensor surface are detectable under certain circumstances.

The sensor design is simultaneously being optimized by means of surface plasmon resonance spectroscopy (SPR). This shows that the protein detection signal measured with aptamer-functionalized gold surfaces is clearly dependent on concentration. The results are reproducible and specific compared with the control surface. Repeated regeneration of biochemical functionalization is possible with only a slight decrease in signal height. With this modification, LTCC sensors can be used in in-vitro diagnostics or biotechnology.

1 *Different LTCC sensor chips with printed gold electrodes.*
2 *Cyclic voltammetry of an LTCC sensor chip.*

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