

Study on Integrated Redox Image Sensor Employing Square Wave Voltammetry

ABSTRACT

In this dissertation, an integrated square wave voltammetry redox image sensor has been developed on the basis of a standard complementary metal-oxide-semiconductor process technology for 2-dimensional chemical imaging and high-scan speed in electrochemical analysis. The field of electrochemical analysis is combined with the semiconductor technology in this study. The square wave voltammetry is a voltammetric technique which can be possible the high speed and high sensitivity measurement compared with cyclic voltammetry. High scan speed is suitable for the array sensor.

For miniaturization and high functional sensor, integration of the electrochemical system is needed. Portable diagnosis and high speed measurement system are developed with the demands for the point of care testing, the simple detecting, and on-site measurements in agriculture, environmental field, and medical science. Bulky external instruments should be miniaturized for simple and fast measurement. Electrochemical sensors using square wave voltammetry based on complementary metal-oxide-semiconductor technology would be possible to solve these requirements.

Square wave voltammetric technology is not new, however so far there is no report about integrated square wave voltammetry circuit on a single chip. The reason is that the general square wave voltammetry technique has a bulky and expensive equipment, and complexity of the measuring equipment. The proposed sensor in this study is the first integrated sensor system of a square wave pulse generator circuit. Compared with conventional square wave voltammetry method, our integrated square wave voltammetry redox sensor system has the advantages of portable diagnosis, on-site analysis, and simple detection. The square wave pulse was observed as expected. We confirmed that the proposed sensor system can detect potassium ferricyanide with good performance by comparison with an electrochemical analyzer. The proposed sensor is designed to control the scan rate, square wave amplitude, and step increment as purposes of measurement. The sensor also shows a good linearity in the range of 0.6 to 6 mM and 20 to 500 Hz. We also successfully obtained the detection limit as low as 0.6 mM under the condition of a higher scan rate than cyclic voltammetry. This is the first objective of our research.

As the next step, array biosensor is considered for chemical imaging. If the electrochemical array sensor technique is established, we can analyze the location information and visualization of biomaterials in a 2-dimensional plane. The integrated square wave voltammetry redox sensor with an 8 x 8 array pixels was fabricated. An 8-bit shift resistor is used for readout signals. We confirmed that the 2-dimensional imaging of potassium ferricyanide was obtained. This result shows the possibility of real-time chemical imaging and has established the basis of the point of care testing.