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B3-3 Biomedical Cation Sensor Using Field Effect of Semiconductor.

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A new method for sensing cation activity in the electrolyte is described. Glass electrode is common for cation sensor. Since the impedance of the glass electrode is very large the glass microelectrode for biomedical purpose is offen difficult to operate as the cation sensor. However this drawback of the glass microelectrode can be overcome by the new type of electrode described in this paper.

The operation of this electrode is similar to that of IGFET (Insulated Gate Field Effect Transistor). Its structure is electrolyte-insulator-semiconductor and the interface potential between electrolyte and the gate insulator controls the conductivity of the semiconductor surface. The mechanism of its cation sensitivity is same as that of usual glass electrode surface i.e. the interface potential varies selectively with the specific cation activity in the electrolyte.

The structure and the photograph of the electrode are shown in Fig.1 and Fig.2 respectively. It is fabricated by the photolithographic technique from p^- type silicon wafer of about 100μm thickness. Source and drain n type diffusion layers are placed at the top side and the bottom side respectively and covered with p^+ channel stopper layer. At the tip of the electrode, the p^+ layer is etched out locally and the source drain diffusion layers are exposed, so that only the tip correspond to the gate channel. As the another part is passivated by the p^+ layer, the instability of the surface is negligible. The tip size is about 60μm.

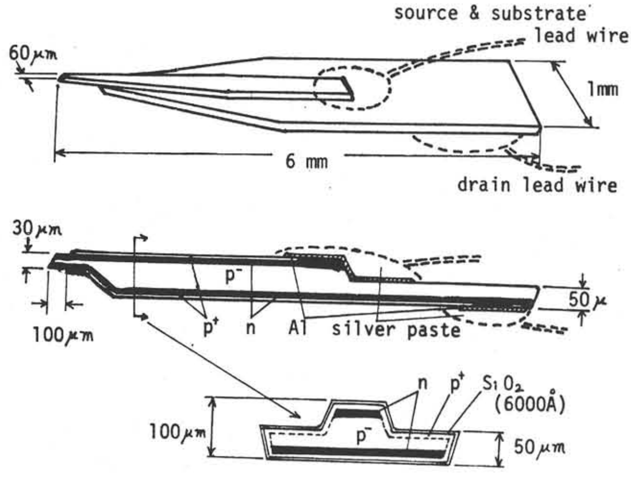

Fig.1 Structure of the cation sensitive microelectrode.

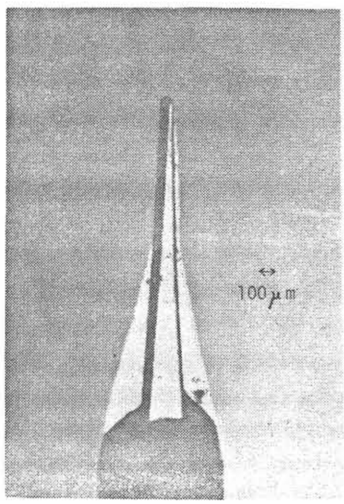

Fig.2 The cation sensitive microelectrode (top view).

The characteristics are measured in 0.9 % NaCl solution by the configuration of Fig.3. Reference electrode of silver-silver chloride corresponds to the gate terminal of FET. The measured drain characteristics and transfer characteristics of common source configuration are shown in Fig.4. Because of its small channel width, the transconductance is small (about 20$\mu℧$) and the equivalent input noise is relatively large (about 1 mV pp). About 15 mV of initial drift voltage is observed for 20 minutes. This drift may be considered to be mainly due to imperfection of gate insulator and may be reduced by the improvement of the fabrication process.

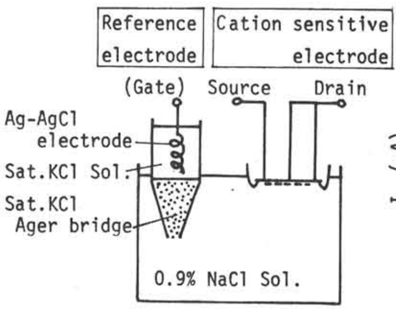

Fig.3 The characteristics measurement configuration.

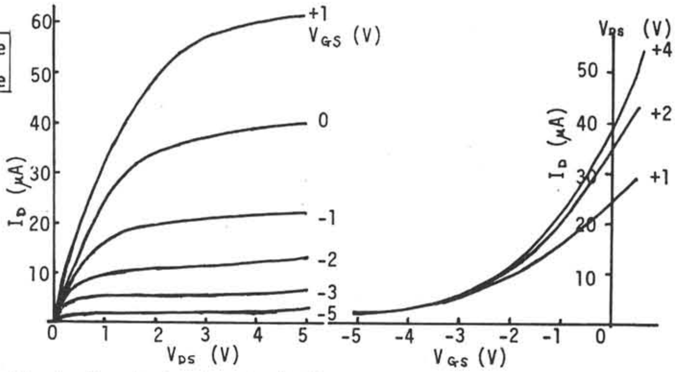

Fig.4 The drain charateristics and transfer characteristics of common source configuration.

The electrode whoes gate insulator surface is silicon nitride is pH sensitive. Its sensitivity to changes in pH is shown in Fig.5. From pH 3 to pH 13, the equivalent interface potential variation is about 60 mV/pH and this agrees with the theoritical Nernst equation (glass electrode theory). However, from pH 0 to pH 2, the potential change is off the theoritical curve and the response is slow. On the other hand in potassium or sodium solution this electrode is not sensitive to their activity.

Thus this electrode can be used as the micro pH sensitive electrode except for the case of low pH. Its long term drift of static characteristics is relatively small. However, because this electrode has photosensitivity, the change of illumination should be avoided when using this electrode.

In the study of the glass electrode, borosilicate glass or aluminosilicate glass is confirmed to be sensitive to potassium or sodium depending with its composition ratio. In future, by suitably treating the gate insulator surface, for example by chemical vapor deposition technique, it might be possible to increase its sensitivity to a paticular ion species. This electrode will be interesting in the study of interfacial phenomena of insulator-electrolyte.

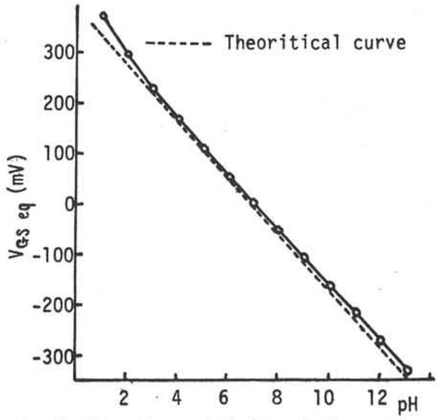

Fig.5 The pH sensitivity of the cation sensitive electrode.