New type of ISFET with separated sensing region from gate-controlled region

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Ion-sensitive field effect transistors (ISFET) have been focused on the sensing of biomolecules due to label-free, highly sensitive and real-time detection. In conventional ISFETs, target molecules bound on the gate dielectric act as charges and thus change the effective gate potential when liquid gate controls the channel surface. In this paper, a new type of ISFET is proposed. The channel of the proposed ISFET is divided into gate-controlled region ($\text{Region}_{\text{gate}}$: the region has the same structure with conventional MOSFETs) and sensing region ($\text{Region}_{\text{sence}}$: the region consists of the gate dielectric and the channel without the gate). The ISFET is operated by controlling the gate voltage of the $\text{Region}_{\text{gate}}$ with the attached biomolecules on the gate dielectric of the $\text{Region}_{\text{sence}}$. When the gate voltage is applied over threshold voltage (V_{th}), the channel resistance of the $\text{Region}_{\text{gate}}$ is sharply decreased and the current of the ISFET is limited by the larger channel resistance of the $\text{Region}_{\text{sence}}$. Thus, the saturation current (I_{sat}) of the ISFET is controlled by the charge of the attached biomolecules on the gate dielectric of the $\text{Region}_{\text{sence}}$.

Our proposed ISFET has many advantages over conventional ISFETs. From TCAD simulations [1], it is found that the proposed ISFET has the higher sensitivity according to pH level than conventional ISFETs due to the unique limitation of the I_{sat} by the channel resistance change of the $\text{Region}_{\text{sence}}$ (Target biomolecules are modeled as equivalent charge on the gate oxide by site-binding model [2] and sensitivity is determined by the change of the I_{sat}). Additionally, the field-dependent drift effect [3] can be mitigated because the attached biomolecules on the gate dielectric of the $\text{Region}_{\text{sence}}$ are hardly affected by the gate voltage. Furthermore, the proposed ISFET has uniform I_{sat} change regardless of V_{th} variation because only the channel resistance of the $\text{Region}_{\text{sence}}$ determines the I_{sat}. This can be a merit in readout circuit system since operating voltage of ISFET can be easily decided.

References

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