DEVELOPMENT AND CHARACTERIZATION OF A HIGH ASPECT RATIO VERTICAL FET SENSOR FOR MOTION DETECTION

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INTRODUCTION

Nowadays, inertial sensors for car dynamics stabilisation, acceleration detection and human body motion monitoring are popular MEMS applications. Additionally, motion/position detection is often required for actuators too (xy stages, switches, etc.). At present, these systems are usually based on piezoelectric or capacitive sensors. While especially the latter principle is already used for mass production of inertial sensors an increase of the signal/area consumption ratio is desired. That’s why alternative approaches have been presented looking for a direct integration of mechanical and electrical principles.

FET SENSOR

The detection principle of the FET sensor for motion sensing is the electrical field effect. A schematic of the structure is shown in figure 1. The system consists of a laterally moving spring-mass-system (figure 2 and figure 3). There are two arms at the seismic mass. Transistor regions are located at the end of the arms (figure 4).

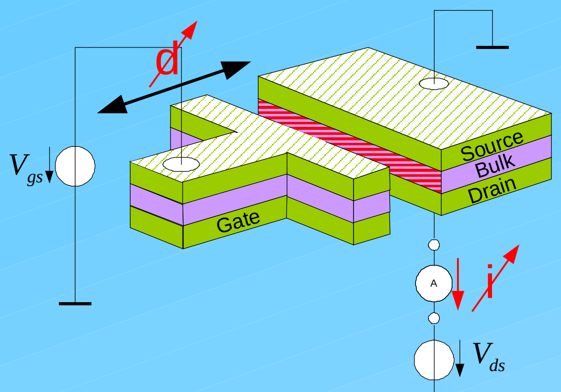


Figure 1: Schematic view of the vertical FET

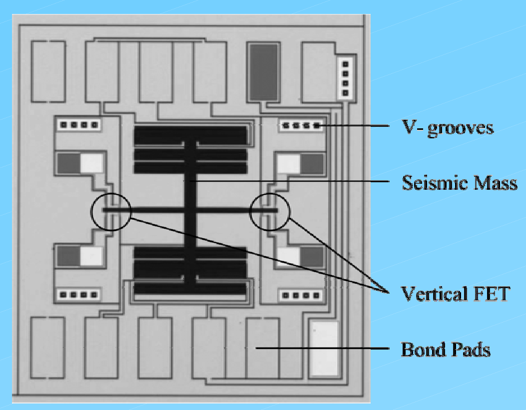


Figure 2: Layout of the transistor

The moving mass (single crystalline silicon) is acting as a in plane gate electrode. The air gap between the channel and the gate electrode decreases / increases due to the deflection of the mass caused for example by the moment of inertia. A displacement of the mass changes the air gap of the vertical FET influencing the capacitance of the gate insulator.

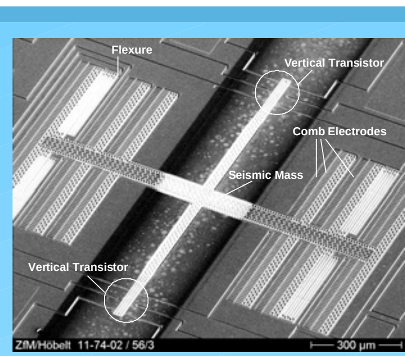


Figure 3: SEM view of the vertical FET

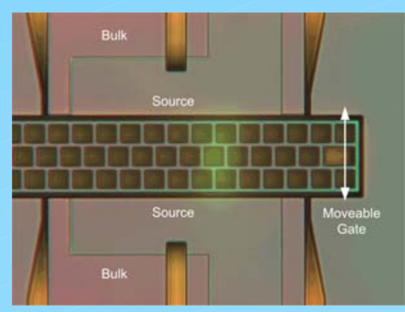
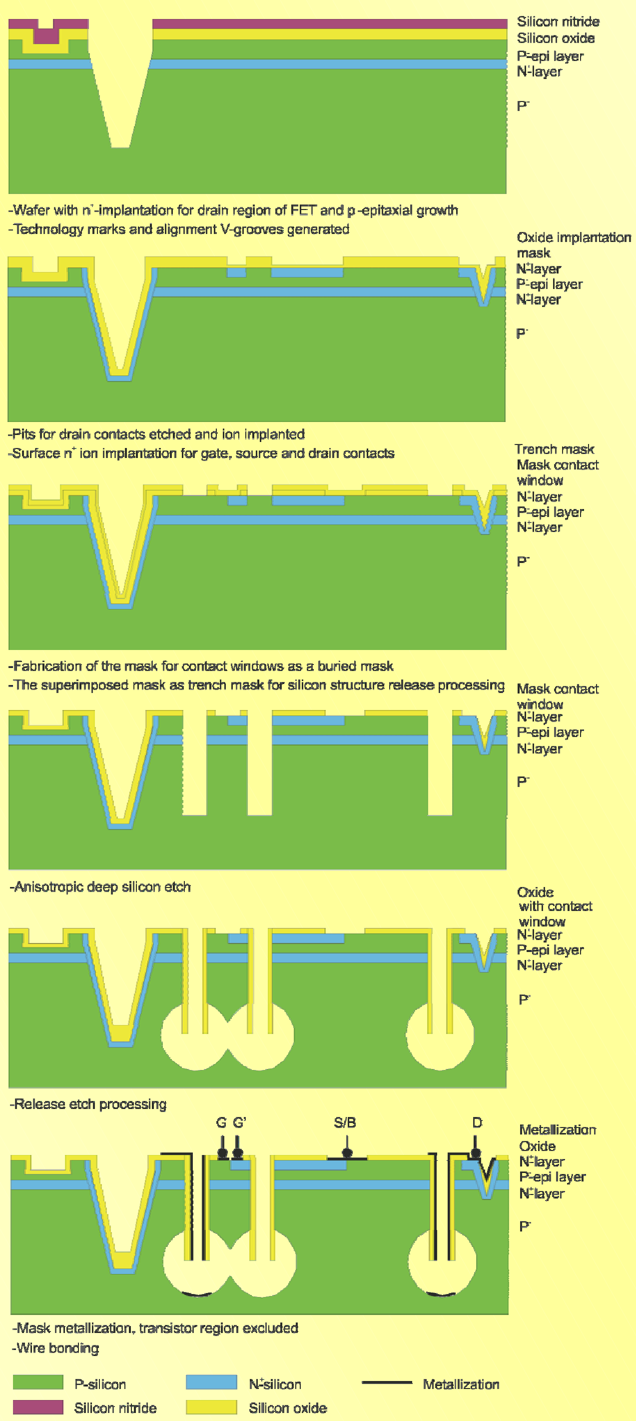


Figure 4: . Light-optical microscope view of the transistor

PROCESS FLOW



EXPERIMENTAL RESULTS

The measurements were carried out on wafer level and on single vertical FET’s. A HP 4062 UX process control system with a HP 4142B modular DC source / monitor was used to bias the gate, drain, source and substrate of the vertical FET. Figure 5 shows the measure arrangement and figure 6 and 7 the results.

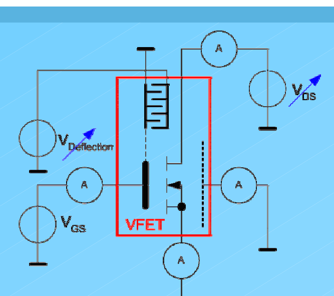


Figure 5:Measure arrangement

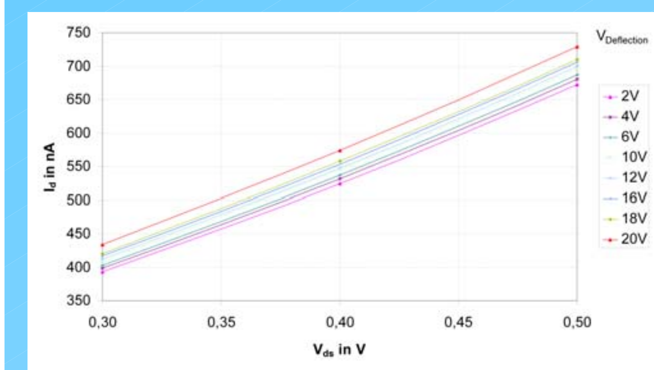


Figure 6: I-U-characteristic depending on deflection voltage

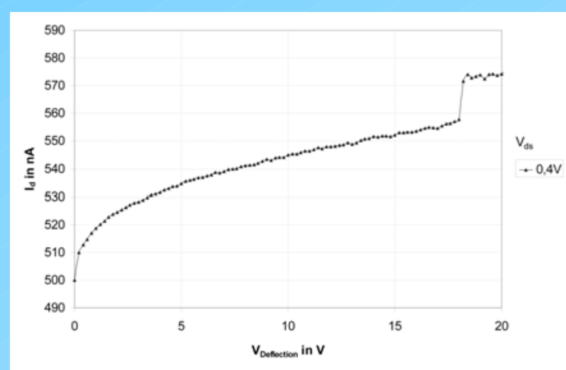


Figure 7: Transfer characteristic at V_{DS}= 0,4 V and V_{GS}= 5 V

SUMMARY

The main advantages of the vertical FET with respect to capacitive sensor systems are:

- higher signal-to-chip size ratio
- simplifications of the signal conditioning circuitry
- low impedance sensing technique
- the sensing element is an “active sensor”
- mechanical movement and output sensor signal are in phase.

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