

Switch Performance Measurement of Junction Field Effect Transistor Integrated in Pixel Sensor

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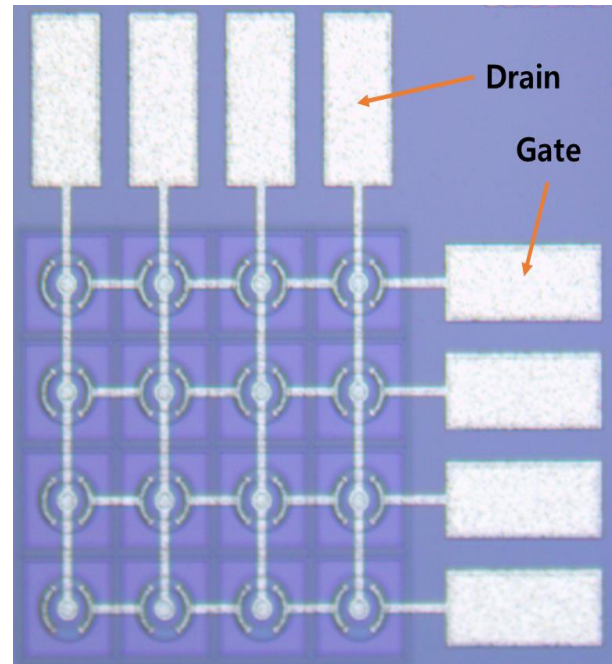
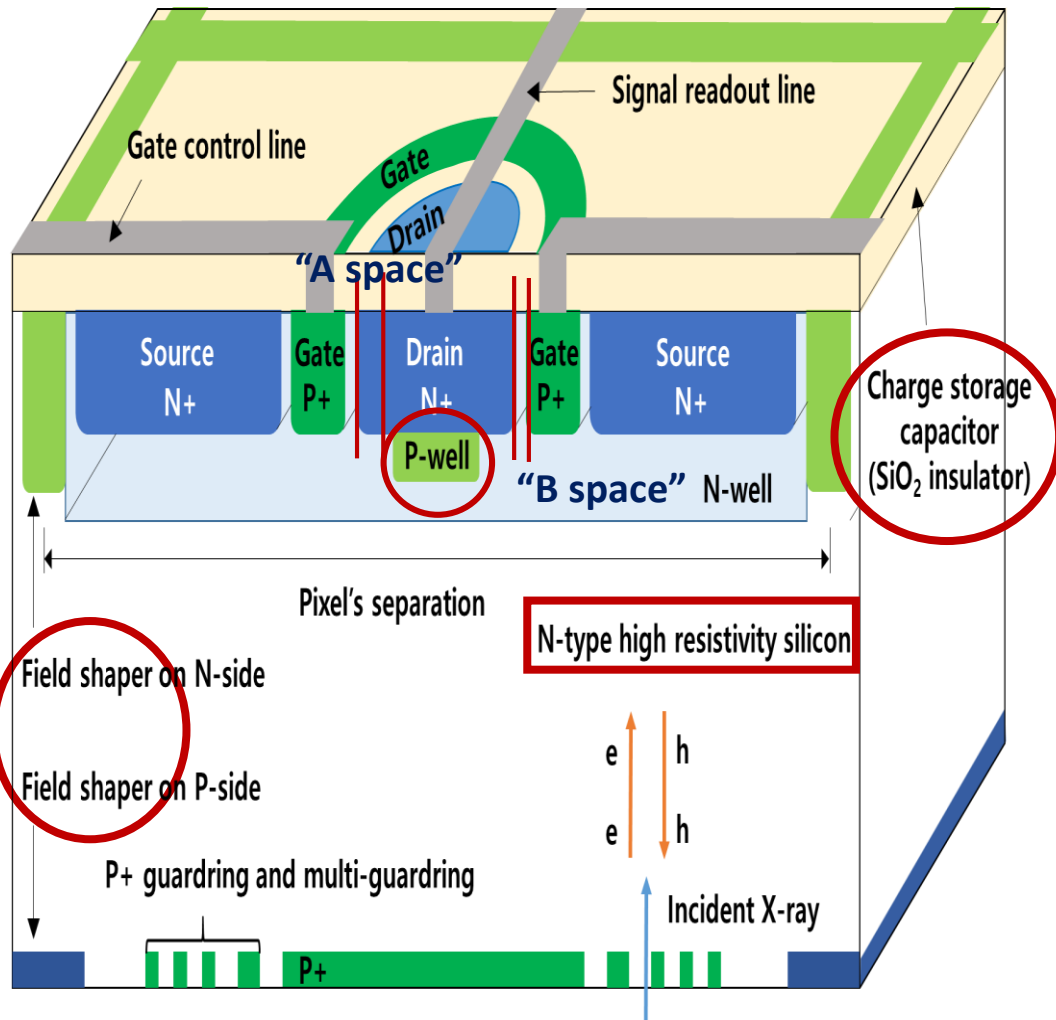
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Design concept of pixelated silicon PIN sensors with JFET structure

Pixel size: 200, 100, 30 μm

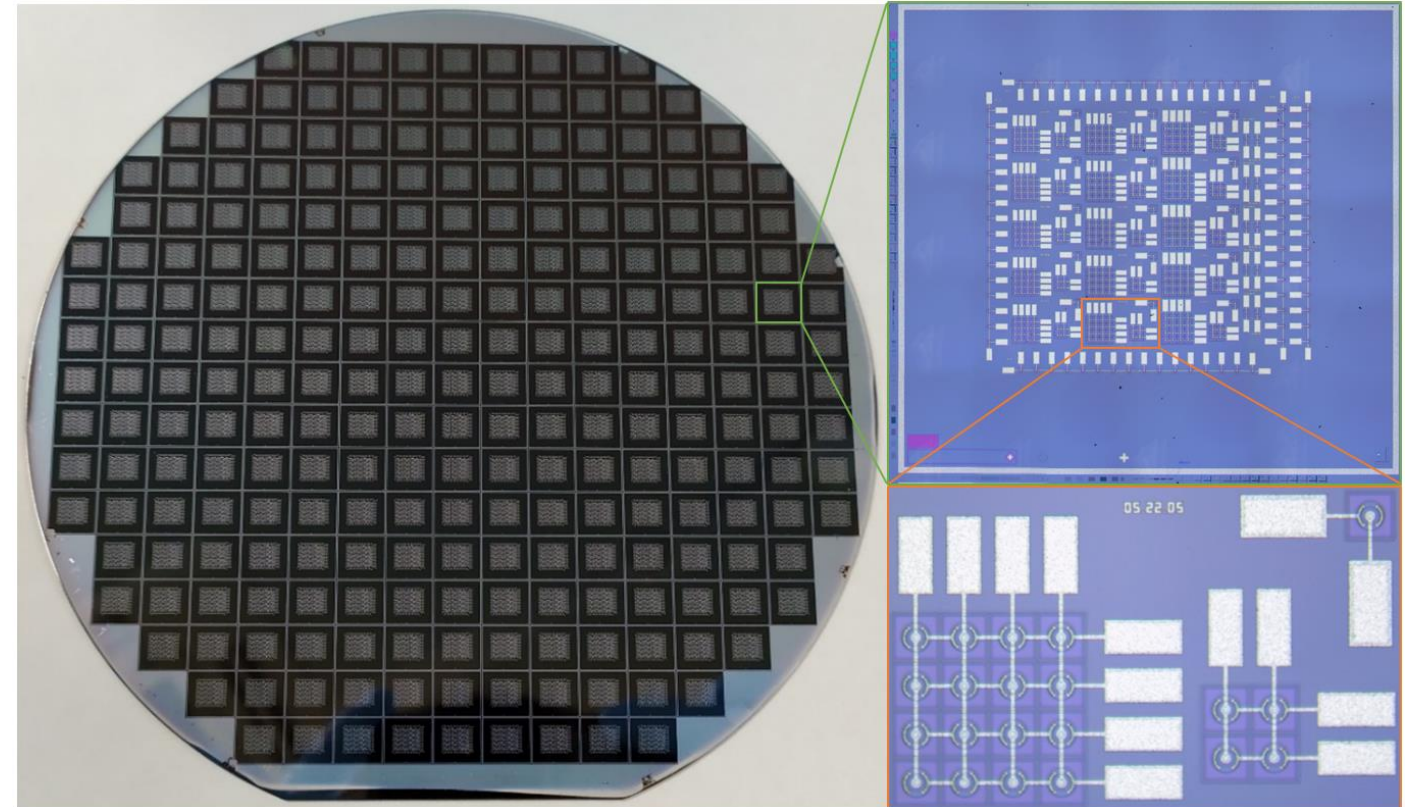
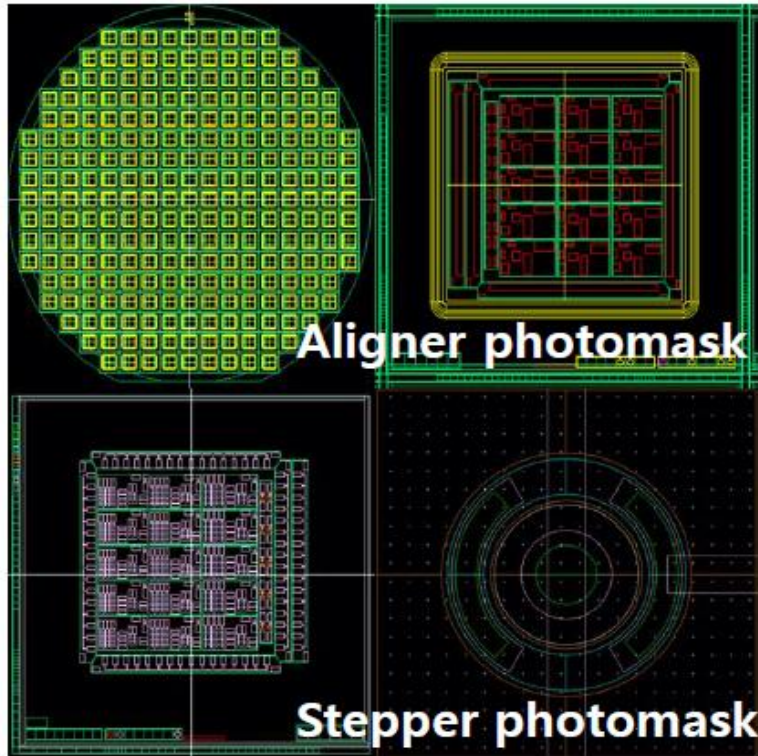
- **PIN structure:** for the detection efficiency for low energy X-ray
 - high resistivity ($>5 \text{ k}\Omega\cdot\text{cm}$) N-type 650 μm thick, 6 in. silicon wafer



- Cylindrical JFET structure
 - switch off : by applying a reverse bias voltage to the gate
 - switch on : charges are transferred from the source to the drain
 - all pixels within one row are read in parallel and the next row is then selected by the control voltage after the previous row's is finished

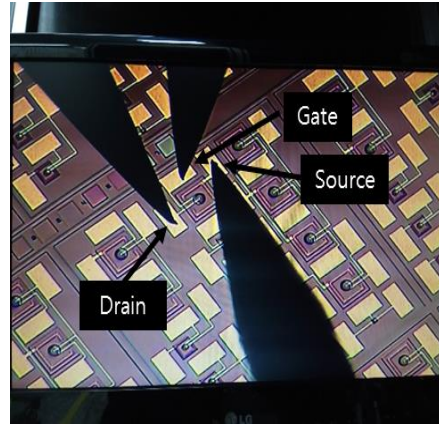
Fabrication

- Design parameters for fabrication
 - P-well doping: 7.0, 7.5, 8.0x10¹³ cm⁻²
 - A space: 0.5, 1.0, 1.4 μm
 - B space: 1.4, 1.8, 2.2 μm
 - C and D spaces: 0, 5, 10 μm



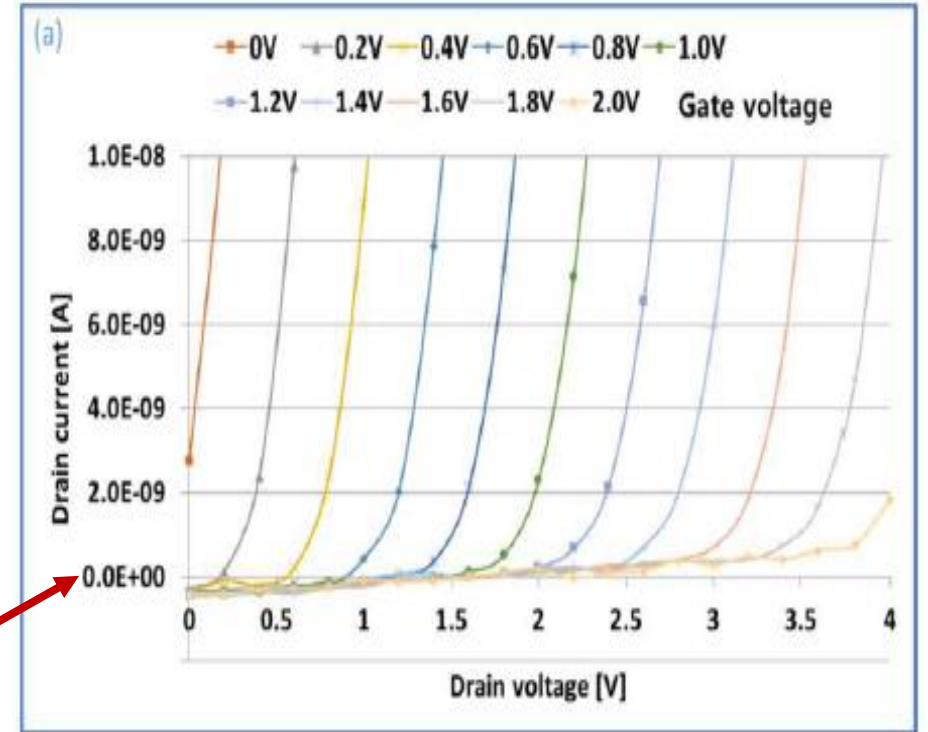
- 1 stepper photomask (6 layer patterns) and 5 aligner photomask
- One of the fabricated wafers on 6-in. wafers with 25 different designs
- Electronics and Telecommunications Research Institute (ETRI) in Korea

Switch Performance Test



For electrical characteristic measurements

I-V characteristics of a JFET for various gate voltages



Pixel size: 100x100 μm^2

B space [μm]		D space 0 μm			
2 nd run	1.4	1.8		2.2	
0.5	Orange	Blue	Blue	Orange	Blue
1.0		Grey	Grey	Grey	
1.4		Grey	Grey	Grey	

C space 0 / 5 / 10 μm

B space [μm]		C space 0 μm			
2 nd run	1.4	1.8		2.2	
0.5	Orange	Blue	Blue	Blue	Blue
1.0		Grey	Grey	Grey	
1.4		Grey	Grey	Grey	

D space 0 / 5 / 10 μm

As expected, the larger the drain voltage at a given gate voltage, the larger the drain current, and the larger the gate voltage, the smaller the drain current.

Summary

- Pixelated silicon sensors with a cylindrical JFET structure were fabricated
- We determined design parameters showing good switching function
 - switching efficiency is improved with a decrease in the JFET size, and with increases in the A and B space values.
 - switch-off resistance of the JFET was found to reach about $10^{10} \Omega$
 - Although this value appears to be relatively low, the switching functioned well for a gate voltage between -1 and -2 V.