A CMOS Image Sensor with 2.0-e\(^{-}\) Random Noise and 110-ke\(^{-}\) Full Well Capacity Using Column Source Follower Readout Circuits

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**Background**

**Graph 1:**
- **Random Noise (Input-referred) [e-]** vs. **Column Readout Gain**
- **With Column Amplifier**
- **Target**

**Graph 2:**
- **Conversion Gain (C.G.) [μV/e-]** vs. **Full Well Capacity (F.W.C.) [e-]**
- **Conventional Sensor**
- **Target**

### Column amplifier
- × Limitation by noises of pixels and amplifiers themselves.
- × Decrease in F.W.C. (\(\sim \frac{1}{30}\))

### Conventional Sensor
- × Trade-off between C.G. and F.W.C.
New Low Noise Readout Circuits

1. Column Readout
   - Gain ≈ 1
   - \( C_{SH} (~5 \text{pF}) \)
   - \( C_p (~0.1 \text{pF}) \)

\[
\frac{C_{SH}}{C_{SH} + C_p} \approx 0.98
\]

2. Minimize \( \sigma_{SF} \)
   - Optimum parameters

3. Eliminate \( \sigma_{\text{off-chip}} \)
   - With CDS function
   - Free from off-chip circuits
Chip Micrograph

- Process Technology
  - 0.18 \( \mu \text{m} \) 2P3M CMOS

- Die Size
  - 5.6 mm\(^H\) \( \times \) 5.8 mm\(^V\)
A low noise and high F.W.C. CMOS image sensor has been developed by using column source follower readout circuits.
Random Noise of Readout Circuits: 0.5 e\textsuperscript{-}

By using developed low noise readout circuits, the behaviors of pixel noises have been accurately measured. 

\textbf{RTS, Flicker noise, Charge transfer noise}

These findings are useful to make pixel noises much lower.