A 2MP Oversampling Image Sensor with 2.75µs Row Time and Conditional Threshold Comparison

Thomas Vogelsang*, Michael Guidash*, Craig Smith*, Jay Endsley*, Loc Truong⁺ and Rami Yassine⁺

* Rambus Inc., + Forza Inc.

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Introduction

- Multibit oversampling presented at IISW 2013
 - Sampling and reset unconditional or conditional
- Test chip target
 - Frame rate sufficient for 12 MP with 30 oversampled frames per second (120 subframes per second)
 - 2.78µs row time required
- 2 MP test chip 320 subframes per second
- Challenges
 - Meet row time requirement

>Overlapping of pixel operations

- Flexible oversampling duration and exposure control without motion artifacts
 - ➢Row address interleaving

Pixel Design



 Per-pixel control of transfer enabled by additional transistor in TG path and column transfer gate

Threshold Assessment



- Partial transfer (raising VTG to intermediate level) allows non-destructive threshold assessment in a 4T pixel
- Assessment of reaching threshold with sense-amplifier
- Multi-bit read of charge after full transfer with ADC

Pixel Operation

Pixel operation with partial transfer

RST	SHR	part TG	part SHS	full TG	full SHS	ADC conversion
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 Two additional operations (partial transfer and SHS of partial transfer signal) are required and need to be included in timing

Pixel Operation Overlapping

RST	SHR	part TX	part SHS	full TX	full SHS	ADC	conve	rsion
ADC conversion			RST	SHR	part TX	part SHS	full TX	full SHS
part SHS	full TX	full SHS	ADC conversion			RST	SHR	part TX

•Time•

 Three time-shifted state machines overlap pixel operations

- One S&H pair for sense-amp (eclipse detect, threshold comparison and saturation detect) is shared
- Each state machine has dedicated S&H pair for conversion

Row Address Interleaving



Architecture



Sensor Chip



Process	TSMC 65nm			
	BSI CMOS IS			
Pixel size	1.4 x 1.4 μm²			
Pixel type	4 x 1 shared			
Pixel array	2016 x 1128			
Active array	1920 x 1080			
Arrays on die	2			
Supply voltages	2.5V/1.3V/1.0V			

Different pixel designs differentiate the two arrays

Pixel Output Waveform



HDR Test Chart and SNR



Summary

- Overlapping row operations enables an effective row time of 2.75 µs required for 4x oversampling of a 12 MP sensor at 30 fps.
- Row address interleaving enables flexible selection of exposure time and subframe durations with concurrent sampling of the subframes.
- Initial test results of a 65nm BSI 2 MP test chip are available, bring-up work is ongoing.