RF and Mixed Signal Capabilities for Advanced Space Systems Based on UTSi® CMOS On Sapphire Technology

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October 2003

Outline

- UTSi CMOS technology overview
- RF & mixed signal capabilities
- RF Integration Examples
  - Single chip MSM
  - Single chip GPS
  - Parallel Optical Modules
Ultra-Thin Silicon, “UTSi”, CMOS Basics

Peregrine Semiconductor

- Patented UTSi® CMOS silicon-on-insulator technology
- Communications markets:
  - Commercial RF & wireless ICs
  - Satellite & mil/aero ICs
  - Photonics devices for datacom
- PSA – wholly-owned fab Australia
  - 6” 0.5 μm process production
  - 0.25 μm in development
  - 3k wafer/month, increasing to 6k
  - 5 week cycle time
  - DD < 1 cm⁻²

San Diego HQ
0.25 um facility
Sydney Fab
UTSi CMOS Benefits

- Very high frequency products:
  - Shipping 6 GHz; 14 GHz in development
  - Competitive with SiGe and GaAs
- Superior functional integration:
  - Mixed RF, analog, digital, EEPROM
  - Very high quality inductors & capacitors
    QL>40 & QC>100@2GHz
  - UV – IR optical and photonics applications
- Design, processing track bulk CMOS:
  - Same tools and equipment
  - Scalable to 0.1 \( \mu \)m (IBM)
- Lower power consumption than SiGe, GaAs or bulk silicon CMOS

UTSi Starting Wafer

- “Twin” Defects
- No Defects

- Conventional SOS
- UTSi CMOS

Epitaxial silicon – 1000A

Sapphire – 600um
UTSi R/H Advantages

- Total dose and SEE hardness are fundamental
- Digital, mixed signal and RF, including excellent passive components
- Built-in EEPROM/flash available
- U.S.-owned fab is supported by commercial business in related areas
- Peregrine Semiconductor is an independent company which has Space & Defense RH ICs as a core business

0.25 um CMOS RF Performance

- Fmax Performance of IN Device

\[
F_{\text{max}} = \frac{f_t}{\sqrt{g_{ds}(R_g+R_s)+2/i_fR_gC_{gd}}}
\]

Device Attributes
- W/L = 250/0.25 um
- Vds/Vgs = 2.5/0.7 V

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UTSi vs. Bulk Si Inductors

Comparison of Spiral Inductor Q Between UTSi and BULK CMOS

- **UTSi**
  - $L = 5\,\text{nH}$
  - $w = 30\,\text{um}$
  - $s = 10\,\text{um}$
  - $r = 300$
  - $n = 3$
  - 4um Metal

- **BULK**

High Q inductors are necessary to match MOS devices.

**RF & Mixed Signal Capabilities**
Peregrine’s Integration Advantage

Intrinsic Sapphire Qualities + CMOS Integration Capabilities = High Value Solutions

Best Phase Noise

Best Linearity

Best Isolation

Best Quality

PLL

Digital control

Mixer

Memory

Switch

Passives

6x4 MSM switch
4.5x4.5 mm

Capitalize on existing RFIC position by delivering highly-integrated module solutions

DSM PLL (-93 dBc/Hz@10 kHz)

Agilent 16:40:09 May 16, 2002

Measure

Monitor Spectrum

Spot Frequency

Log Plot

Carrier Freq: 1.955 GHz Signal Track: Off
DAWN: Off Trig Free

Log Plot

Carrierm Power: -10.00 dBm Attenu: 0.00 dB
Ref: -60 dBc/Hz Mkr1: 10.00 kHz

10.00 dB

100 Hz

Frequency Offset

10 MHz

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2 GHz, 57 Hz step size
PE84122 1.9 GHz Mixer

- IP3>+30
  - IP3 20 dB above LO drive
- Integrated RF & LO phase shifters
- <8 dB IL @ 2 GHz
- >35 dB iso @ 2 GHz

Tuning for different frequencies done in M2 & M3

Passive FETQUAD

EEPROM Basic PlusCell™

- Unique cell offers embedded EEPROM with no extra masks or processing
  - Cell fully tested over radiation temp, endurance & retention
  - Transistors are fully depleted
  - PE9721 (EEPLL) is 1st product
  - Available in ASIC or custom with hand layout (no compiler yet)
Avalanche Injection Mechanism

Electrons are injected for $V_p$ applied to PMOS device

Integration Examples
**4x6 MSM Matrix Switch**

- 900 MHz power splitters, PE4460
- RF switch matrix
- Digital control interface (SPI)
- 1800 MHz power splitters

**4.5 mm**

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**Single Chip, Dual-band, A/J GPS Receiver**

- ~20 L’s
- ~50 C’s
- ~100 R’s
- ~30 switches
- ~4k gates
- 2 A/D’s
- 3 LDO’s
- Synergistic system & chip design
- Customer Saves:
  - 90% parts
  - 75% area
  - 50% cost
  - 25% power
UTSi CMOS T/R Block Diagram

Overview of FOCUTSpak technology: FOCUTS™

Flipped Optoelectronic Chips on UTSi®
FOCUTS™ for Parallel Optical Interconnects

- FOCUTS™ with integrated guide pins mate to MTP parallel fiber connector
- Single component contains:
  - ICs
  - OE devices
  - MTP interface

Conclusions

- UTSi CMOS on sapphire is a high performance semiconductor technology which integrates RF, mixed signal, digital, EEPROM, passives and optical devices
- Products today cover from DC to Ku band, qualified at virtually all space manufacturers
- Contact Peregrine Semiconductor KK for inquiries