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ADVANCED SUBSTRATE NEWS™

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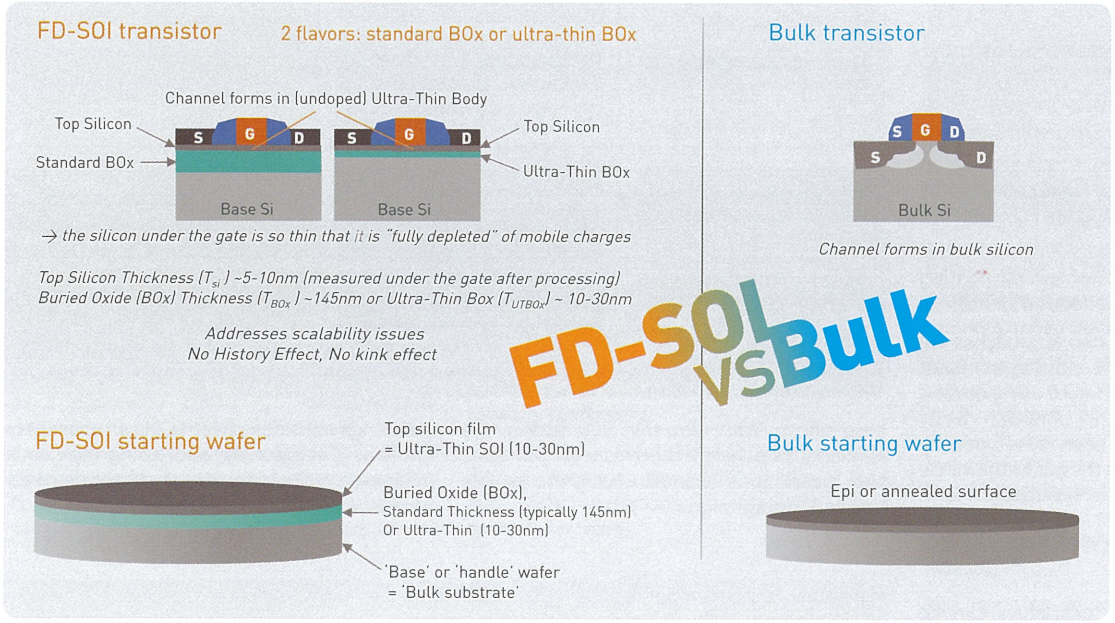
Tech Special: **FD-SOI**

INTRO

FULLY DEPLETED (FD) SOI FOR THE NEXT GENERATION

FD-SOI is making the move towards industrialization. In this issue of *ASN*, experts from **IBM**, **ST**, **Hitachi**, **Leti** and **Soitec** detail their approaches.



AN FD-SOI **PRIMER**

What is it ?

In planar FD-SOI (as opposed to the verticality of FinFETs), CMOS transistors are built into an ultra-thin layer of silicon over a Buried Oxide (BOx) (which can optionally be extremely thin, too). This makes them Ultra-Thin Body Devices, with unique characteristics.

Why use it?

Planar FD-SOI addresses the major scaling challenges beyond the 28nm node:

- Lowering supply voltage (V_{DD} – hence power consumption per device) while boosting the dynamic performance;
- Stopping – even better, reversing – the dramatic increase of variability in transistor characteristics;
- Continuing to shrink transistor dimensions while limiting leakage and other unwanted short channel effects.

As a result, the unique properties of fully depleted devices – combined with the simplicity of a planar FD-SOI process and optimized wafer costs – put FD-SOI in the cost-of-ownership "sweet spot" for finished chips.

For which applications?

The primary application targets of FD-SOI are low power Systems-on-Chips (SOCs), including those that need to combine demanding dynamic performance with low (static and dynamic) power consumption. That covers markets such as: Cellular Telecom, Mobile Internet Devices (Smartphones, Tablets, Netbooks), Home and Mobile Multimedia, etc.

When will it be ready?

FD-SOI is a very serious candidate for mainstream technology at the 22/20nm low power node, which targets qualification around the end of 2012. Many extremely encouraging results have already been reported by different technology R&D teams, with recent updates at IEDM in December 2009. More broadly:

- industrial wafers in line with the tight requirements of FD-SOI are available;
- the fab toolset is the same as for bulk CMOS;
- and the design flow is not disruptive. •

See the SOI Industry Consortium website for an in-depth FAQ on FD-SOI.

TO YOUR **HEALTH**

Medical electronics represent one of the industry's fastest growing segments*. At the intersection of patient needs and technology innovation, SOI can help deliver advanced features in smaller, lower power devices.

*Source: Databeans 2009 Medical Semiconductors report

X-RAY VISIONARIES

Developed for use in high energy particle physics, applications for KEK's new SOIPIX technology can also extend to medical imaging.

MEDICAL CHALLENGE

The medical community is looking to tools developed for particle physics to solve a host of diagnostic and therapeutic challenges. On the diagnostic side, digital X-ray systems with semiconductor radiation detectors (in which sensor arrays replace film) offer greater anatomical precision, higher sensitivity, higher speed (so lower radiation dosage) as well as more functional information (such as density). Doctors would also like to see X-ray systems integrated with complementary systems such as MRI, and in vivo imaging techniques. On the therapeutic side, small, low-power, radiation-hardened detectors could be leveraged in real-time, integrated, tunable dosimetry for radiotherapy. But as always, the bottom line is cost.

DESIGN CHALLENGE

In conventional bulk CMOS technology, X-ray imaging sensors and associated readout electronics are typically produced separately, then bump-bonded. They need to be smaller, cheaper, faster, higher performance and lower power.

SOI SOLUTION

KEK* scientists, working with an international team, have developed a new detector technology for high energy particle physics, which they call silicon-on-insulator pixel (SOIPIX).

In KEK's SOI solution, the sensor and its associated electronics are produced together on a single chip, separated by just a very thin, insulating Buried OXide (BOX) layer.

The ingenuity of the KEK detector design is that it uses the silicon substrate as the sensor. This arrangement reduces the parasitic capacitance in the device, and speeds the readout. As is always the case with SOI, the insulator reduces leakage current, resulting in a faster, lower-power device.

Beyond particle physics, SOI advantages specific to the SOIPIX detector are also applicable in the context of medical X-ray sensors:

- insulation between the pixels protects them from electrical signals generated by neighboring pixels – so the pixels can be smaller and more sensitive, for higher performance imaging in a smaller system
- the thickness of the sensor can be adjusted – so it can fit in a smaller package
- operation over a much broader temperature range – heat dissipation is a major challenge in the design of radiographic systems
- radiation hardness – making them suitable for medical X-ray and radiotherapeutic systems
- lower power – which particularly benefits moves to smaller, mobile or in vivo systems

SOIPIX is now KEK's largest and best-funded international project, with 16 partners including Fermilab, Lawrence Berkeley, and several European institutions. Research is ongoing, exploring next steps such as vertical integration. OKI Semiconductor provides its industry-leading expertise in FD-SOI design, and fabricates the chips in multi-project wafer (MPW) runs. •

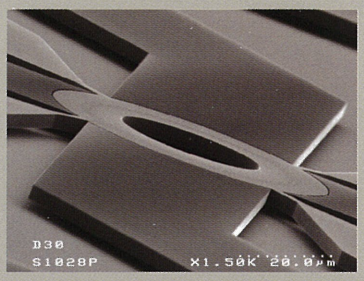
Part of this article was adapted from a feature on the KEK website, www.kek.jp. Many thanks to Dr. Yasuo ARAI, leader of the KEK SOI group, for his help.

*KEK is Japan's High Energy Accelerator Research Organization.

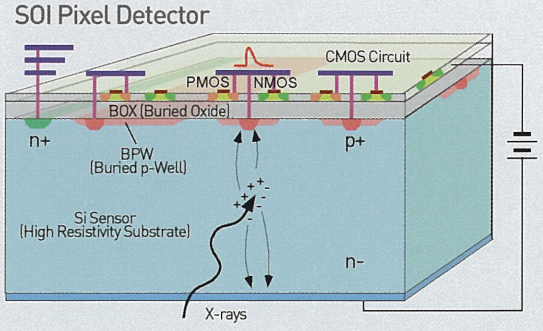
IN THE LAB

"Currently at Leti, we use SOI in health-related research more for dimensional requirements than intrinsic electrical properties. For example, reproducibility in the cavity size (z-axis) is of prime importance for dilution and biological protocols. Some specific studies in capacitive detection, however, do leverage the electrical advantages of SOI."

*– **Jean CHABBAL**, Vice President Technologies for Biology and Healthcare **CEA Leti***



Suspended ring implemented as an oscillator mass sensor for label-free biological detection
(Courtesy: CEA Leti)



SOIPIX is a technology that combines the sensor and read-out electronics on a single semiconductor device. (Courtesy: KEK)

Multi-project wafer (MPW) wafer runs by OKI Semiconductor handle multiple designs from institutions collaborating on SOIPIX R&D.
(Courtesy: KEK)

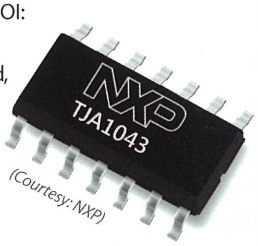
Advanced Substrate Industry Buzz

What's New. What's Hot. What's Next.

(Courtesy: STMicroelectronics)

STMicroelectronics' SOI-BCD6 technology combines low-voltage CMOS logic, precise analog circuitry and robust power stages on the same ultrasound pulse controller chip. By integrating the transmit/receive switch, the STHV748 minimizes the number of external components required in applications such as stationary and portable ultrasound scanners, giving medical designers further miniaturization and cost reduction.

- **Cissoid** further extends its lines of SOI-based products for high-temperature environments with a DC-DC converter platform, fast drivers for power transistors, and power MOSFETs.
- New SOI-based products from **Freescale**:
  - the MSC825x family of programmable DSPs delivers the optimal blend of low cost and the industry's highest performing core for a broad range of medical, aerospace/defense and test/measurement applications.
  - the QorIQ P1012/P1021 for communications equipment applications – the first processors based on its QorIQ communications platform that also incorporate QUICC Engine multiprotocol technology.
- SOI news from **Seiko Instruments**, Inc.: a start-up IC for DC/DC converters with input voltage as low as 0.3V, and a high precision silicon-based MEMS resonator leveraging manufacturing technology that greatly improves the impact of temperature fluctuations on resonant frequencies.
- **Clare**/IXYS's latest line-up on SOI includes the CPC9909 high-voltage LED driver with >90% efficiency and the IX2127 high-voltage gate driver IC.
- From **Soitec**:
  - teaming with TowerJazz to offer a backside illumination platform for high-end image sensors
  - volume production of a new generation of high-resistivity SOI substrates for cellular phone and Wi-Fi markets
  - joining forces with CEA-Leti to speed commercial adoption of 3D integration
  - supplying SOI substrates to CSMC in China for display and other applications
- With its high-voltage SOI process, **Atmel**'s new ATA6663/64 transceiver families for LIN automotive networking applications take 10x less wake-up power and can reduce system costs by 40%.
- **Telefunken Semiconductors** is expanding its high-voltage SOI-based foundry offerings for automotive, industrial and power management.
- **Skyworks**' new antenna switch modules for 2/3/4G handset and data card platforms use both GaAs and SOI technologies.
- **Tronics** will produce high-performance, vacuum-packaged inertial MEMS accelerometers and gyroscopes invented, designed and patented by Thales, for the stringent navigation requirements of aircraft, satellites and other platforms.
- **AMO** leads a new 3-year European research program, PLATON, which will integrate electronics, photonics and plasmonics on an SOI motherboard chip for Tb/s back-plane or blade-server interconnects.
- **Plessey Semiconductors** is releasing a range of SOI-based amplifiers, demodulators, synthesizers and high-speed pre-scalers for the defense, space, general communications, automotive and industrial control market segments.
- New from **NXP** on SOI:
  - for automotives, the most-advanced, high-speed CAN transceiver, the TJA1043;

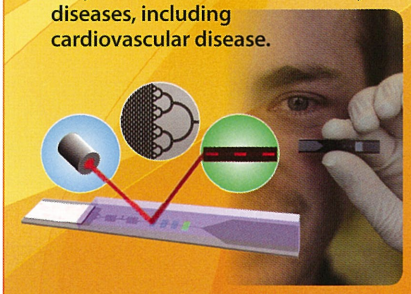


(Courtesy: NXP)

  - for ultra-slim power supplies for TVs, PCs and more, the GreenChip TEA1713 resonant half-bridge converter.
  - the GreenChip TEA1733(L) - a low-cost IC that increases energy efficiency and standby performance of power supplies under 75W.
- **Kulite**'s new lines of SOI-based pressure transducers target high-temperature industrial, military and aerospace markets.

IBM's recent SOI news:

- As reported in Nature, the nanophotonic avalanche photodetector is the fastest of its kind and could enable breakthroughs in energy-efficient computing that can have significant implications for the future of electronics.
- **IBM scientists have created a one-step point-of-care-diagnostic test, that requires less sample volume, is significantly faster, portable, easy to use and can test for many diseases, including cardiovascular disease.**



(Courtesy: IBM Research - Zurich)

THANK YOU!

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