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A Second-Order ΣΔ ADC Using Sputtered IGZO TFTs

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Foreword

The materials science of thin films and associated fabrication process technologies continue to stimulate new technologically significant application areas related to human-machine interaction. A good case in point is the active matrix display, which relies on a layer of thin-film transistor (TFT) electronics (referred to as the display backplane) to drive the display. The backplane is crucial from the standpoint of speed, resolution, and stability, including instability compensation. An interesting material that has emerged for the backplane is the metal oxide semiconductor. The material is transparent and low-temperature processible making it amenable for layering on plastic or even paper substrates. Fully transparent displays have been demonstrated by leading companies such as LG or Samsung, which are starting to create new application areas such as smart windows for automobiles and buildings and immersive environments. These applications place new demands on the TFT, which now will have to go beyond its standard role as a simple switch to new circuit functions.

This book is an abridged version of the materials science and characterization of oxide TFTs tailored to circuit applications. Following a short introduction, the operating principles of TFTs addressing materials selection are covered in Chap. 2. Processing techniques for TFTs along with materials characterization are addressed in Chap. 3 followed by the theory, operation, and current state of the art of thin-film analog-to-digital converters (ADCs). Implementation considerations are reported in Chap. 5 with emphasis on the comparator and sigma-delta modulator ($\Sigma\Delta$M). The book concludes with future perspectives of materials and ADC architectures.

While the design concepts and circuits demonstrated here are based on metal oxide TFT technology, the design considerations can be adapted to a broader range of materials families that support p-channel transistors.

The book is well written and will benefit the engineering design community, materials scientists, physicists, and chemists who are looking for applications of new materials. The book can also serve as a useful reference for graduate or short courses in universities or industry. The authors are renown in the area of oxide TFTs.

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Arokia Nathan

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Contents

Symbols

C_i	Gate capacitance per unit area
E_B	Breakdown field
E_C	Conduction band
E_G	Bandgap
f_{co}	Cut-off frequency
F_{in}	Input frequency
F_S	Sampling frequency
g_{DS}	Conductance
g_m	Transconductance
I_{DS}	Drain-to-source current
I_G	Gate leakage current
J	Current density
k	Extinction coefficient
L	Channel length
n	Refractive index
N	Resolution
S	Subthreshold slope
V_{DD}	Positive power supply
V_{DS}	Drain-source voltage
V_{GS}	Gate-source voltage
V_{on}	Turn-on voltage
V_T	Threshold voltage
W	Channel width
κ	Dieletric constant
μ_{eff}	Effective mobility
μ_{FE}	Field-effect mobility
μ_{sat}	Saturation mobility

Acronyms

ADC	Analog-to-digital converter
AFM	Atomic force microscopy
ALD	Atomic layer deposition
AMLCD	Active matrix liquid crystal display
BW	Bandwidth
CEMOP	Center of Excellence in Microelectronics Optoelectronics and Processes
CENIMAT	Centro de Investigação de Materiais
CT	Continuous time
CTS	Centre of Technology and Systems
CVD	Chemical vapor deposition
CMOS	Complementary metal oxide semiconductor
DAC	Digital-to-analog converter
DR	Dynamic range
DRC	Design rule check
DSP	Digital signal processor
DT	Discrete time
EDA	Electronic design automation
EDS	Energy-dispersive X-ray spectroscopy
ENOB	Effective number of bits
ESD	Electrostatic discharge
FET	Field-effect transistor
FFT	Fast Fourier transform
FPD	Flat panel display
IC	Integrated circuit
IGZO	Indium-gallium-zinc oxide
IGO	Indium-gallium oxide
IMO	Indium-molybdenum oxide
IZO	Indium-zinc oxide
JFET	Junction field-effect transistor
LTPS	Low-temperature polycrystalline silicon

LSB	Least significant bit
LVS	Layout versus schematic
MESFET	Metal semiconductor field-effect transistor
MIM	Metal insulator metal
MIS	Metal insulator semiconductor
MISFET	Metal insulator field-effect transistor
MOSFET	Metal oxide field-effect transistor
MSB	Most significant bit
OLED	Organic light-emitting device
OSR	Oversampling rate
PCELL	Parameterized cell
PDK	Process design kit
PECVD	Plasma-enhanced chemical vapor deposition
PFBL	Positive feedback latch
PVD	Physical vapor deposition
RF	Radio-frequency
RIE	Reactive ion etching
SEM	Scanning electron microscopy
SAR	Successive approximation register
SNDR	Signal-to-noise plus distortion ratio
SNR	Signal-to-noise ratio
TCO	Transparent conducting oxide
TEM	Transmission electron microscopy
TFT	Thin-film transistor
TLM	Transmission line method
TSO	Transparent semiconducting oxide
UNINOVA	Instituto de Desenvolvimento de Novas Tecnologias
XRD	X-ray diffraction
ZTO	Zinc-tin oxide
$\Sigma\Delta$	Sigma-delta
$\Sigma\Delta$M	Sigma-delta modulator