Ultra-Low Power Devices for Advanced Signal Processing Architectures,
Arokia Nathan, Cambridge Touch Technologies, University of Cambridge

AROKIA NATHAN (S'84-M'87-SM'99-F'10) received the Ph.D. degree in electrical engineering from the University of Alberta. Following post-doctoral years at LSI Logic Corp., USA, and ETH Zurich, Switzerland, he joined the University of Waterloo, Canada, where he held the DALSA/NSERC Industrial Research Chair in sensor technology and subsequently the Canada Research Chair in nano-scale flexible circuits. He was a recipient of the 2001 NSERC E.W.R. Steacie Fellowship. In 2006, he moved to the UK to take up the Sumitomo Chair of Nanotechnology at the London Centre for Nanotechnology, University College London, and subsequently held the Chair of Photonic Systems and Displays in the Department of Engineering, Cambridge University, where he led a multi-disciplinary research group working on the heterogeneous integration of materials and processes, sensors, energy harvesting and storage devices pertinent to wearable technologies. He is currently the Chief Technical Officer of Cambridge Touch Technologies, a company spun out of his lab at the University of Cambridge developing advanced interactive technologies. He received the Royal Society Wolfson Research Merit Award and recently the BOE Distinguished Contribution Award for TFT Compact Modeling and Circuit Design. He has held Visiting Professor appointments at the Physical Electronics Laboratory, ETH Zürich and the Engineering Department, Cambridge University, UK. He has published over 600 papers in the field of sensor technology, CAD, thin film transistor electronics, and is a co-author of four books. He has over 100 patents filed/awarded and has founded/co-founded four spin-off companies. He serves on technical committees and editorial boards in various capacities. Dr. Nathan is a Chartered Engineer (U.K.), Fellow of the Institution of Engineering and Technology (UK), Fellow of IEEE (USA), and an IEEE/EDS Distinguished Lecture

Abstract: Thin film semiconductor materials, such as oxides and organics, are becoming key for the future flexible electronics because of their potentially wide band gap, hence high transparency and low OFF current, compared with the ubiquitous silicon counterparts. These material systems can be processed at low temperature and at low fabrication cost, which makes them amenable for integration on a wide range of substrate materials including plastic and paper. This course will review the new generation of applications using selected oxides and organics ranging from large area flexible electronics to the newly emerging Internet of Things. While the thin film transistor continues to evolve, producing devices with higher mobility, steeper sub-threshold slope and lower threshold voltage, practical analog signal processing circuits are constrained by issues related to non-uniformity, electrically- and illumination-induced instability, and temperature dependence. We will discuss the critical design considerations of displays, sensors and sensor interfaces, along with advanced signal processing architectures, to show how device-circuit interactions should be handled and how compensation methods can be implemented. In particular, the quest for low power becomes highly compelling in newly emerging application areas related to wearable devices in the Internet of Things. We will discuss thin-film transistor operation near the OFF state, driven by the pivotal requirement of low supply voltage and ultralow power. The operation of the wearable device is challenged by limited battery lifetime even if augmented with energy harvesting. One of the key requirements for design of flexible electronics for these emerging applications is physically-based circuit models, which requires good knowledge of the underlying transport mechanisms in the thin film transistor, and in particular, the associated density of states and field-effect mobility. The major developments in thin film transistor modeling for computer-aided design of circuits and systems will be reviewed, along with simple and compact analytical description of the current-voltage characteristics of thin film transistors in the above-threshold and sub-threshold regions for expedient circuit simulations.