Ph.D. in Information Technology: Theses Defenses

January 17th, 2018

DEIB Beta Room (building 24)

9.30 am

First Ph.D. presentation and discussion:

Mario LAUDATO – XXX Cycle

“Study of novel devices for crosspoint memory and neuromorphic applications”

Advisor: Prof. **Daniele Ielmini**

Abstract:

This doctoral dissertation is focused on the electrical characterization of select devices (SD) based on amorphous materials (SiOx and a-Si) and emerging memristors (PCM and RRAM) for neuromorphic and crosspoint memory applications. The objective of the research is in the first part aimed at comprehensive study of the most promising select devices in order to enable crosspoint memory technology. In the second part the work is addressed to development and implementation of a neuromorphic hardware with phase change memory (PCM) synapses, where pattern learning and recognition is operated by spike-timing dependent plasticity (STDP) in individual synapses.

Second Ph.D. presentation and discussion:

Paolo MINOTTI – XXX Cycle

“Towards Fully-Integrated Frequency-Modulated MEMS Gyroscopes”

Advisor: Prof. **Giacomo Langfelder**

Abstract:

This thesis reports the developments towards the integration of a tri-axial, consumer-grade, frequency-modulated MEMS gyroscope. A custom low-power, low-phase-noise integrated circuit is designed specifically for frequency-modulated operation. Both yaw- and pitch-rate, analog-output sensing systems based on Lissajous frequency-modulation are experimentally demonstrated for the first time, by coupling the developed circuit with two novel micromachined structures fabricated with a 24-µm-thick industrial process.

In operation, both gyroscopes show a repeatable and stable scale factor, with less than 0.55% of part-to-part variability, obtained without any calibration, and 35 ppm/°C of variability over a 25° to 70°C temperature range. The whole system achieves a 10-mdps/rt-Hz resolution with a 500-µA current consumption only. The design of a frequency-digitization circuit, required to provide a digital-output sensor, is reported, but not experimented. As a conclusive remark, a system-level performance comparison with conventional amplitude-modulated MEMS gyroscopes is carried out.

Third Ph.D. presentation and discussion:

Davide RESNATI – XXX Cycle

"Physical modeling of nanoscale NAND Flash memory reliability"

Advisor: Prof. **Christian Monzio Compagnoni**

Abstract:

Flash memory technology dominates today's data storage market, being able to provide high integration density, low costs and good reliability, mainly with memory arrays relying on the NAND architecture. The continuous scaling of the technology that allowed this success led to cell dimensions below 20nm, which, however, resulted also in an increased impact of single electrons in the gate stack on device threshold voltage (VT). This introduced many reliability constraints caused by the capture and emission of electrons by interface traps and defects in the cell tunnel-oxide, which must be studied from a discrete and statistical point of view. The need to prolong Flash technology scaling, in the impossibility of further reducing cell dimensions without compromising reliability, led to the design of three-dimensional (3-D) NAND Flash arrays, as opposed to the conventional planar arrays. While 3-D Flash technologies allowed to trade off a relaxation in the feature size with an increased number of stacked layer of NAND cells in the vertical direction, the materials and architectural solutions introduced with 3-D integration brought to light new phenomena undermining the stability of cell VT and ultimately the reliable operation of the memory array. Aim of the present dissertation is the analysis and understanding of VT instabilities in NAND Flash arrays and their statistical features, with the ultimate goal of providing predictive tools able to assess the on-field operation of the memory array. This was done, first, by focusing on random telegraph noise (RTN) and charge detrapping from tunnel-oxide defects, which represent the main sources of VT time instabilities in planar NAND arrays. Furthermore, operating temperature plays a notable role in determining the value of cell VT and its instabilities, with an increased importance of temperature in 3-D NAND technologies due to the use of polycrystalline silicon as channel material. This work addressed temperature effects in NAND arrays, with a detailed comparison of the differences in the impact of a temperature change on planar NAND arrays and 3-D NAND arrays, which paves the way for the development of models able to capture these effects in modern 3-D NAND

technologies.

PhD Committee:

Prof. **Christian Monzio Compagnoni**, DEIB – Politecnico di Milano

Prof. **Marco Bernasconi**, Università di Milano Bicocca

Prof. **Cristian Zambelli**, Università di Ferrara