Mattia Segatto, Ph.D.

Education

2020 – march 2024 — **Ph.D. in Industrial and Information Engineering**, University of Udine.
Thesis title: *Modeling and Simulation of Ferroelectric-based Devices for Neuromorphic Computing Applications*. Supervisor: Prof. David Esseni

2018 – 2020 — **M.Sc. Electronic engineering**, University of Udine.
Thesis title: *Correnti di tunnelling assistito da trappole in giunzioni tunnelling con materiali ferroelettrici per paradigmi computazionali neuromorfici*. Supervisor: Prof. David Esseni, co-supervisor: Prof. Francesco Driussi

2013 – 2018 — **B.Sc. Electronic Engineering**, University of Udine
Thesis title: *Effetto del tunneling inelastico nelle caratteristiche di rumore 1/f nei transistori MOSFET*. Supervisor: Prof. Pierpaolo Palestri

Research Activity

Key Contributions

A significant part of his research was dedicated to Ferroelectric Tunnel Junctions, which hold promise for creating artificial neurons and synapses with reduced power consumption compared to conventional neural networks.

PostDoc Research (2023-current)

His PostDoc research activity has been carried out in the context of the project "Ferroelectric Neuromorphic Learning for Tactile Edge Application (FeNeL)", where he leveraged on the experitse matured during his Ph.D. activity to explore, study and model novel applications of ferroelectric devices as synaptic hardware, such as ferroelectric memcapacitors. Given the complex nature of the devices under study, the simulations of these devices' behavior were carried out using the commercial TCAD software framework developed by Synopsys, specifically Sentaurus Device.

Ph.D. Research (2020-2023)

His Ph.D. research program extended this expertise to encompass the modeling and simulation of ferroelectric materials and ferroelectric-based devices, specifically targeting hardware applications in neuromorphic computing. In the later stages of his Ph.D., Mattia Segatto explored novel aspects of ferroelectric materials. He adapted the Landau-Ginzburg-Devonshire (LGD) theory to anti-ferroelectric materials, focusing on analytical extraction of their anisotropy coefficients [2]. He also investigated an innovative approach to describing ferroelectric materials using the LGD theory based on extrinsic events, offering a novel perspective compared to existing literature.

M.Sc. Research (2020)

During his Master's Degree thesis, Mattia Segatto specialized in analytical modeling of trap-assisted tunneling current in Ferroelectric Tunnel Junctions.

Research Activity (continued)

Collaborative Research

Mattia Segatto was an active contributor to the European Project H2020 BeFerroSynaptic GA:871737 (2020-2023). He is currently employed with a research grant funded by the Italian Ministry of University and Research (MUR) through the project "Ferroelectric Neuromorphic Learning for Tactile Edge Application (FeNeL)" in the category "Progetti Di Ricerca Di Rilevante Interesse Nazionale – Bando 2022".

Research Support Activity

2021 "Algorithm development and software implementation for parallelized computation and simulation of electronic devices based on ferroelectric materials" at University Of Udine.

2023 "Characterization and modelling of the dynamics of ferroelectric materials for electronic devices applications" at University Of Udine.

Skills

Languages	English: Full professional proficiency. Italian: Native
Numerical Simulation	Synopsys Sentaurus, Applied Materials Ginestra, In-house Ferroelectric Simulator [3], [7]
Coding	MATLAB, Python, Latex, CUDA, C, C++
Office Automation	Microsoft Office Suite, Microsoft Word, Microsoft Excel, Microsoft PowerPoint

Simulation Expertise

His research involved comprehensive characterization of ferroelectric devices, encompassing both Large-Signal [4], [6], [12] and Small-Signal operation [11] through numerical simulations with both in-house developed and commercial software (Synopsys toolkit).

Software Development

Since 2021, he actively contributed to the in-house simulation tool for ferroelectric materials and devices developed by the Nanolectronics Devices and Components (NEDeC) group at the University of Udine.

Research Publications

Journal Articles

1. J. Barbot, R. Fontanini, M. Segatto, *et al.*, "Dynamics of polarization loss and imprint in bilayer ferroelectric tunnel junctions," *Journal of Applied Physics*, vol. 134, no. 21, p. 214 102, Dec. 2023, ISSN: 0021-8979. DOI: 10.1063/5.0176374.
2. M. Segatto, F. Rupil, and D. Esseni, "Analytical procedure for the extraction of material parameters in antiferroelectric zro2," *IEEE Transactions on Electron Devices*, vol. 70, no. 6, pp. 3037–3042, 2023. DOI: 10.1109/TED.2023.3265626.
3. R. Fontanini, J. Barbot, M. Segatto, *et al.*, "Interplay between charge trapping and polarization switching in beol-compatible bilayer ferroelectric tunnel junctions," *IEEE Journal of the Electron Devices Society*, vol. 10, pp. 593–599, 2022. DOI: 10.1109/JEDS.2022.3171217.
4. R. Fontanini, M. Segatto, K. S. Nair, *et al.*, "Charge-Trapping-Induced Compensation of the Ferroelectric Polarization in FTJs: Optimal Conditions for a Synaptic Device Operation," *IEEE Transactions on Electron Devices*, vol. 69, no. 7, pp. 3694–3699, 2022. DOI: 10.1109/TED.2022.3175684.

5. M. Hoffmann, M. Gui, S. Slesazeck, *et al.*, "Intrinsic nature of negative capacitance in multidomain $Hf_{0.5}Zr_{0.5}O_2$-based ferroelectric/dielectric heterostructures," *Advanced Functional Materials*, vol. 32, no. 2, p. 2 108 494, 2022. DOI: https://doi.org/10.1002/adfm.202108494.

6. M. Segatto, R. Fontanini, F. Driussi, D. Lizzit, and D. Esseni, "Limitations to Electrical Probing of Spontaneous Polarization in Ferroelectric-Dielectric Heterostructures," *IEEE Journal of the Electron Devices Society*, vol. 10, pp. 324–333, 2022. DOI: 10.1109/JEDS.2022.3164652.

7. R. Fontanini, M. Segatto, M. Massarotto, *et al.*, "Modeling and design of ftjs as multi-level low energy memristors for neuromorphic computing," *IEEE Journal of the Electron Devices Society*, vol. 9, pp. 1202–1209, 2021. DOI: 10.1109/JEDS.2021.3120200.

Conference Proceedings

1. D. Esseni, F. Driussi, D. Lizzit, M. Massarotto, and M. Segatto, "Modelling and simulations of ferroelectric materials and ferroelectric-based nanoelectronic devices : (invited paper)," in *2023 International Conference on Simulation of Semiconductor Processes and Devices (SISPAD)*, 2023, pp. 9–12. DOI: 10.23919/SISPAD57422.2023.10319574.

2. S. Lancaster, M. Segatto, C. Silva, *et al.*, "Reducing the tunneling barrier thickness of bilayer ferroelectric tunnel junctions with metallic electrodes," in *2023 Device Research Conference (DRC)*, 2023, pp. 1–2. DOI: 10.1109/DRC58590.2023.10187018.

3. M. Massarotto, M. Segatto, F. Driussi, *et al.*, "Bridging large-signal and small-signal responses of hafnium-based ferroelectric tunnel junctions," in *2023 35th International Conference on Microelectronic Test Structure (ICMTS)*, 2023, pp. 1–6. DOI: 10.1109/ICMTS55420.2023.10094178.

4. M. Segatto, M. Massarotto, S. Lancaster, *et al.*, "Polarization switching and ac small-signal capacitance in ferroelectric tunnel junctions," in *ESSDERC 2022 - IEEE 52nd European Solid-State Device Research Conference (ESSDERC)*, 2022, pp. 340–343. DOI: 10.1109/ESSDERC55479.2022.9947185.

5. R. Fontanini, J. Barbot, M. Segatto, *et al.*, "Polarization switching and interface charges in beol compatible ferroelectric tunnel junctions," in *ESSDERC 2021 - IEEE 51st European Solid-State Device Research Conference (ESSDERC)*, 2021, pp. 255–258. DOI: 10.1109/ESSDERC53440.2021.9631812.

6. E. Caruso, F. Bettetti, L. D. Linz, D. Pin, M. Segatto, and P. Palestri, "Modeling 1/f and lorenzian noise in III-V mosfets," in *2019 International Conference on Simulation of Semiconductor Processes and Devices (SISPAD)*, 2019, pp. 1–4. DOI: 10.1109/SISPAD.2019.8870548.

Speaker at Conferences

2024 — Oral contribution at NamLab "High K Workshop", 11-12 March 2024, Dresden (Germany), with the presentation titled *Modelling of Ferroelectric Tunnel Junctions: Depolarization fields, charge trapping and multi-level operation*

2022 — Oral contribution at IEEE 52nd European Solid-State Device Research Conference (ESSDERC), 19-22 September 2022, Milan (Italy) with the presentation titled *Polarization Switching and AC Small-Signal capacitance in Ferroelectric Tunnel Junctions*