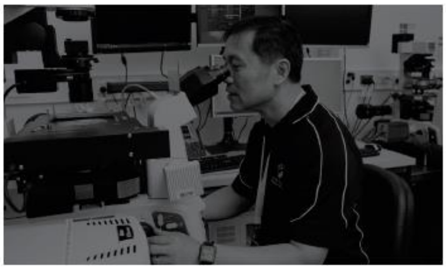

Single-electron tunneling through dopants in thin-Si devices

Dr Daniel Moraru[1,2]
Associate Professor
[1]Research Institute of Electronics, Shizuoka University, Japan
[2]Faculty of Science, Swinburne University of Technology

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151 Wellington Road, Clayton, 3168
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Meeting ID: 812 9011 2054 and passcode: 443815

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A/Prof Daniel Moraru
Research Institute of Electronics
Shizuoka University, Japan
E: moraru.daniel@shizuoka.ac.jp
W: https://wwp.shizuoka.ac.jp/morarulab/

Abstract:
Electronics has been progressing at a fast, but steady pace over many decades along the Moore's law: making devices smaller and smaller by various breakthroughs in technology and engineering, and by finding innovative ways to couple them into complex circuits. However, an aim is to develop atomic-level functionalities using even single dopants in Si, as demonstrated with a long-term purpose to quantum computing.[1] In our lab, we have pursued a new direction of research into atomic- and molecular-scale electronics using dopant atoms (or "molecules") in silicon: dopant-based electronics.[2] This is based on a welldeveloped platform for fabrication of silicon nano-devices, but changing the active unit in transport to be the dopant-atoms substitutionally embedded in the Si crystalline matrix. Along this approach, we fabricate, characterize and simulate ultimately-small Si devices (with dimensions on the order of 10 nm), as schematically shown in Fig. 1(a), looking for signatures induced by such dopant-atoms in different regimes of dopant concentration [see Fig. 1(b)]. Although randomly doped, we can identify single-electron tunneling (SET) in silicon-on-insulator nanodevices via individual donors[3-6] or via clusters of donors[7-10] working as quantum dots, not only in transistors, but also in tunnel diodes.[11] Recently, we reported for the first time room-temperature single-electron tunneling through dopant-based QDs in highly-doped silicon-on-insulator field-effect transistors, with channels patterned to have nanoscale dimensions. In such nano-channels, due to the random distribution of donor-atoms, we can identify devices in which clusters of a few donors form quantum dots with barriers sufficient high to sustain SET operation even up to T=300 K.[12] These results are promising to demonstrate single-electron control in transport under practical conditions, building a pathway towards applications.

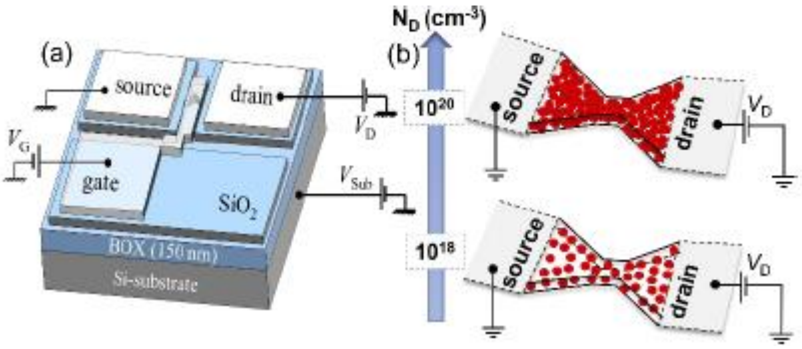

Fig. 1.(a) Schematic illustration of a biased SOI-FET. (b) Nanoscale channels doped with P-donors at different dopant concentrations.

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Daniel Moraru has been working on the development of a unique research direction for semiconductor nanoscale devices, aiming for atomic- and molecular-scale electronics by utilizing dopant atoms (or dopant clusters as "molecules") in silicon. Through such research, he and his group have been contributing to the advancement of a field coined as "dopant-based electronics". In his lab, research is performed from different perspectives, from first-principles simulations of atomistic effects to Si nanodevice fabrication and electrical characterization at the level of single-electron tunneling.

Daniel received his PhD (Dr. Eng.) in Nanovision Science and Technology from Shizuoka University in 2007, working afterwards for several years as a post-doctoral researcher in the Research Institute of Electronics. Since 2012, he has been an Assistant Professor, and since 2015, an Associate Professor at Shizuoka University, establishing his research group that addresses quantum effects, in particular dopant-based effects, in silicon nanodevices. The long-term target is the development of novel functionalities at molecular and atomic level on the CMOS-compatible Si platform. Currently, he is a Visiting Associate Professor at Swinburne University of Technology for several months.

He has more than 65 scientific papers and contributed to more than 300 presentations in international conferences, as well as domestic conferences in Japan. For the research work carried out with his team, he received the Young Researcher Award SSDM at the International Conference on Solid State Devices and Materials in 2006, the Young Scientist Oral-Presentation Award JSAP from the Japan Society of Applied Physics in 2007, and the Young Scientist (Gold) Award at the meeting of IUMRS-ICEM (International Union of Materials Research Societies & International Conference on Electronic Materials) in 2013, among others.

Contact information and reference links
Homepage: https://wwp.shizuoka.ac.jp/morarulab/
LinkedIn: https://www.linkedin.com/in/danielmoraru/
Research Gate: https://www.researchgate.net/profile/Daniel-Moraru
ORCiD: https://orcid.org/0000-0002-8087-8344