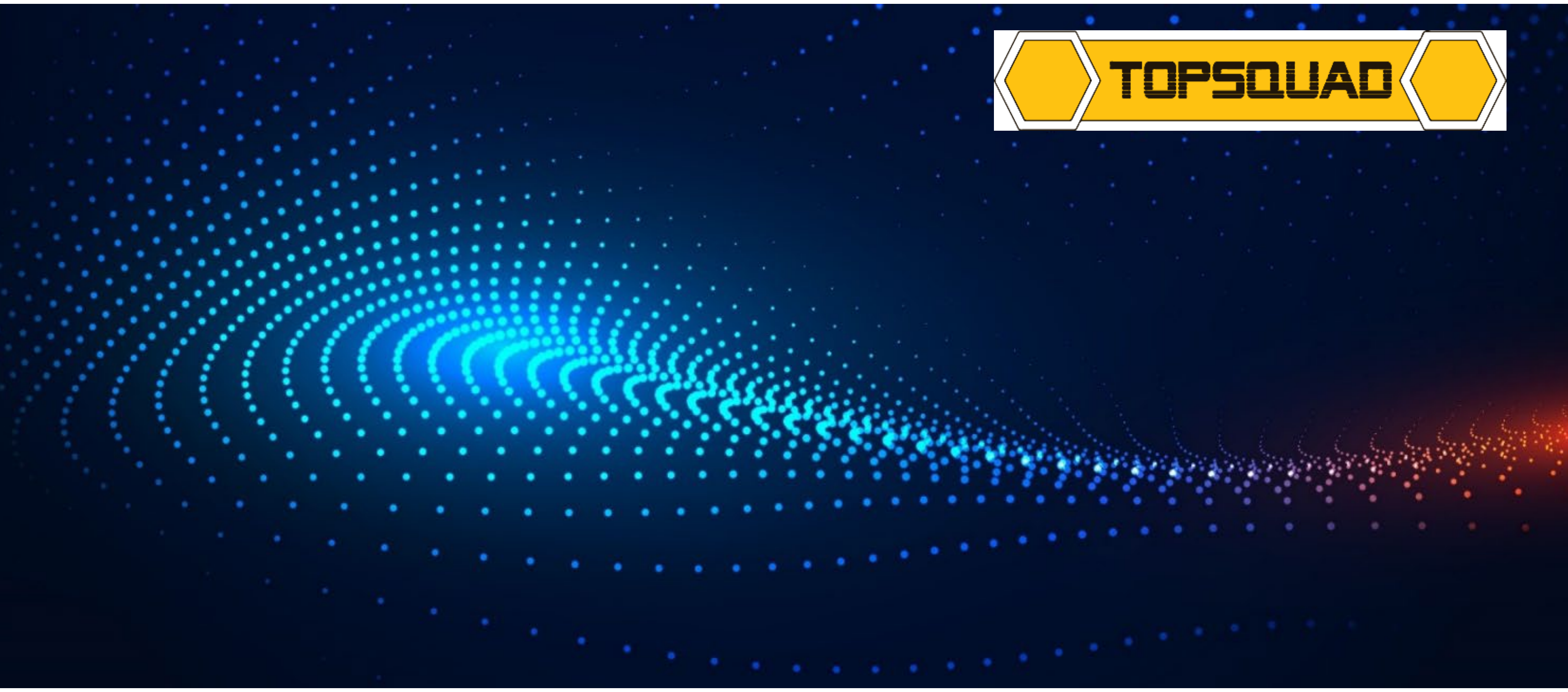
THE TOPFORCE



TOPSQUAD 2nd year bulletin February 2022

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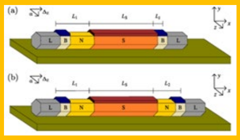

Ge quantum wells: new material platform in TOPSQUAD
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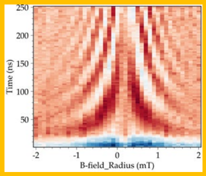


Basel Precision Instruments - Giving researchers a better lens into the quantum world
by Parisa Fallahi, CEO at BASPI

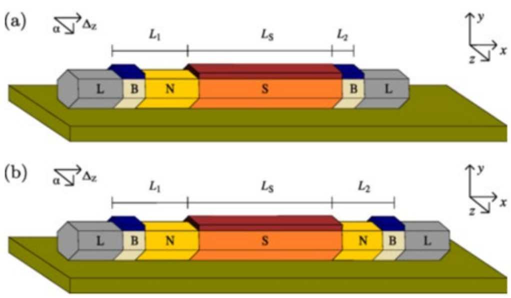
The TOPSQUAD project has received funding from the European Union's Horizon 2020 research and innovation programme. Grant agreement: 862046. Funded under: H2020-EU.1.2.1. - FET Open.

A TOP continuation for TOPSQUAD

- by project coordinator Floris Zwanenburg and project manager Gabi Maris

The second year was marked by the completion of the TOPSQUAD team and by important scientific steps towards the project goals. The new members quickly integrated and strenghtened the stimulating environment of our closely collaborating team. Our partner from IST Austria initiated the study of the Ge quantum wells, a new material platform promising for on-chip co-integration of spin qubits with superconducting technologies. Significant steps have been made on the control of the in-plane growth of the Ge-Si nanowires and the development of devices. The transport measurements have shown induced superconductivity in the nanowires through the silicon shell, a novelty in this platform, which is crucial to avoid the metallization problem.

New insights into the understanding of topologically protected quantum bits in Ge-Si nanowires.



Different configurations of the nanowire setup [1].

The theoretical results of Richard Heß et al. [1] from our University of Basel partner were published in Physical Review B and indicate that trivial Andreev Bound States can generate conductance measurements features that can mimic Majorana Bound States (MBS). Thus, the conductance measurements of correlated Zero-Bias Peaks (ZBP) at the ends of a typical superconducting nanowire or an apparent closing and reopening of the bulk gap in the local and non-local conductance are not conclusive indicators for the presence of MBSs.

The paper demonstrates that it is essential to perform measurements in systems with long superconducting sections and over a large parameter space if one wishes to gain confidence in a purported MBS signature.

A rich palette of communication, dissemination and exploitation activities.

The consortium continued to actively reach out to its main stakeholders. The project's results have been presented at various conferences and events. With the support of Golden Egg Check, important steps have been made for the project's exploitation efforts including a detailed market analysis for nanoPHAB. Futhermore, low threshold dissemination and tutorial videos have been developed by our partners in Eindhoven, nanoPHAB and Basel. TOPSQUAD coordinator Floris Zwanenburg gave an interview on Dutch national radio about quantum physics and technology dedicated to a broad audience.

Interview Floris Zwanenburg at Dr. Kelder & Co, NPO Radio 1.

Source:

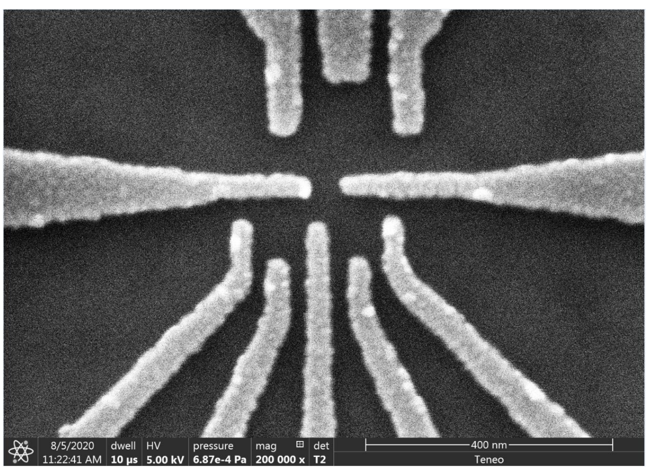
[1] Richard Heß et al.: Local and nonlocal quantum transport due to Andreev bound states in finite Rashba nanowires with superconducting and normal sections, Phys. Rev. B 104, 075405 (2021).

Ge quantum wells: new material platform in TOPSQUAD

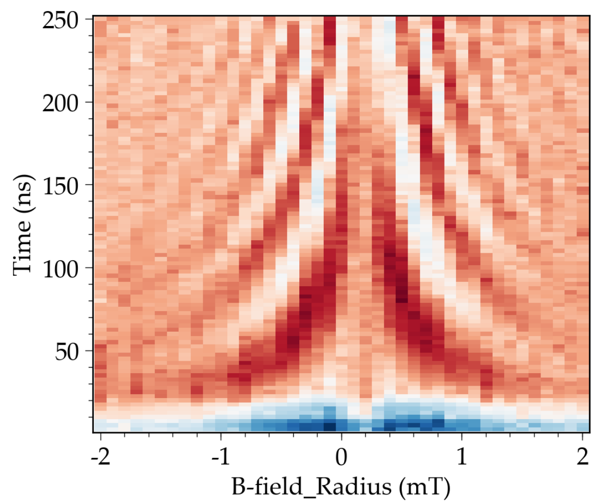
- **by the group of Georgios Katsaros, IST Austria**

The Ge quantum wells are studied in TOPSQUAD as a new material platform next to the Ge-Si core-shell nanowires. This platform replaces the Ge hut-wires initially investigated in the project and for which a too large Schottky barrier prohibited the observation not only of the superconductivity, but also the observation of any measurable normal state conductance by using superconducting electrodes.

These Ge quantum wells, grown in the group of Giovanni Isella at Politecnico of Milano, are investigated at IST Austria because of their potential as a platform for fully electrically tunable spin-orbit qubits and are particularly attractive in terms of scalability. The large out of plane g-factor differences in quantum dots formed in this material has allowed the realization of a low field singlet-triplet qubit, as recently reported in Nature Materials by the Katsaros group from IST Austria [2]. These findings emphasize the potential of this material for on-chip co-integration of spin qubits with superconducting technologies. The strong spin orbit energy of Ge [3], similar to what has been reported for III-V materials, make these Ge hole gases not only a suitable platform for spin qubits but also for investigating topological superconductivity.



Scanning electron microscope image of a double quantum dot device with a charge sensor used for realizing a low-field singlet-triplet qubit. [2]



S-T_0 oscillations in a double quantum dot device in planar Ge.

Sources:

[2] D. Jirovec et al.: A singlet-triplet hole spin qubit in planar Ge, Nature Materials (2021).

[3] R. Mizokuchi et al.: Hole weak anti-localization in a strained Ge quantum well, Applied Physics Letters (2017).

Read more about our research and interest at: https://nanoelectronicsgroup.wordpress.com/

Basel Precision Instruments - Giving researchers a better lens into the quantum world

- by Parisa Fallahi, CEO BASPI

Basel Precision Instruments GmbH is a spin-off of the University of Basel, Switzerland. BASPI offers some of the world's lowest noise and most stable lab electronic instruments and most efficient microwave filtering solutions for quantum and low-temperature experiments. BASPI's products are in use in over one hundred labs worldwide, making possible ground-breaking quantum experiments and giving researchers better control, lower electron temperatures, and significantly reduced noise. With a growing team, broadening customer base, and expanding product portfolio, BASPI is fueling the 2nd quantum revolution!

Within the framework of TOPSQUAD, BASPI has enjoyed collaborating with some of the world's top experts to develop instrumentation matching the needs of TOPSQUAD's challenging experiments. As a result of this collaboration, BASPI is releasing a new version of its LNHR DAC voltage source in 2022, with an increased number of channels (12 or 24), 1'000x higher speed (up to 100 kHz bandwidth), AWG functionality for fast scans, improved stability (at ppm level), still very low noise and several other features meeting the needs of today's quantum experiments. BASPI's new LNHR DACII is the best instrument on the market for controlling sensitive DC lines such as quantum gates. For orders in 2022, BASPI is offering the new DAC with introductory pricing at a 15% discount level.

BASPI's new LNHR DACII.

As a small and growing company, BASPI is dedicated to educating and promoting young scientists and entrepreneurs and enhancing the number of females in high tech. Towards this end, and with the support of TOPSQUAD, BASPI is offering a number of secondment opportunities on several topics:

- Voltage Source Cryogenic Microwave Filter and Thermalizer (MFT).
- Low-Noise High-Resolution DAC.
- Python and QCoDeS Interfaces for LNHR DACII.
- Automization of Test Setups.

Three stacked MFT filter boxes under test in a cryo-free dilution fridge at University of Basel.

Find more about us on https://baspi.ch