Since the summer of 2015 the spin qubit team lead by Lieven Vandersypen (as well as the groups of Leo DiCarlo, Koen Bertels and Edoardo Charbon) is actively collaborating with Intel Corporation. Since then both Giordano Scappucci and Menno Veldhorst started their own groups in QuTech's Fault Tolerant Quantum Computing road map and joined the efforts towards a spin qubit based quantum processor. Next to Intel, QuTech also has a collaboration with Microsoft, which to some extent even goes further than the collaboration with Intel, since an entire Microsoft lab is being built in our university building, called Microsoft Station Q at Delft.

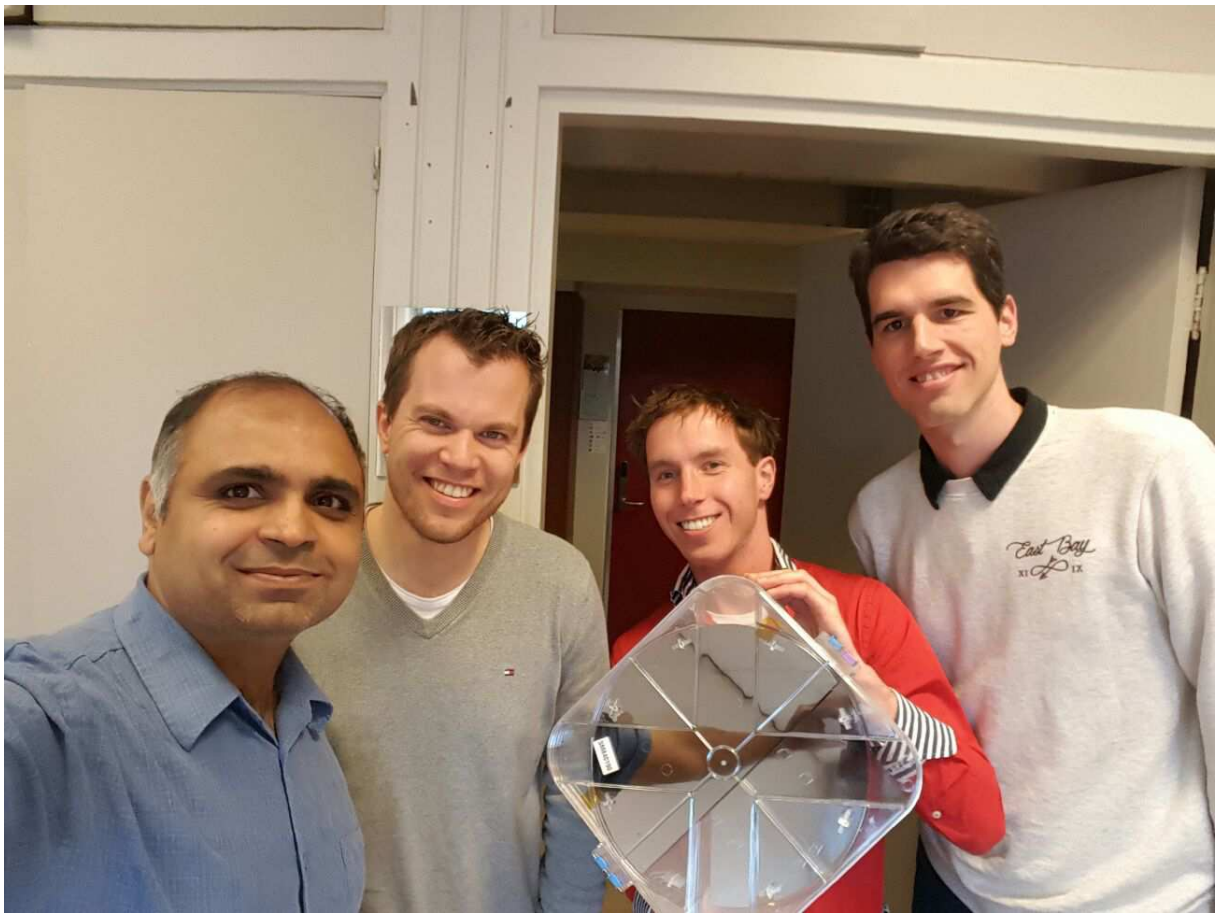
The collaboration with Intel is more than regular research funding, which makes it unique in its kind. Intel has never before worked together with academia so closely, while QuTech now has access to knowledge, expertise and facilities to which (almost) no other university has had access before. It's this what makes the collaboration a real win-win by fulfilling Intel's desire to learn about quantum and QuTech's wish for more uniform and reproducible qubits. Intel and QuTech joined forces and agreed on a strong collaboration for 10 years. It's an active collaboration with material and samples going in both directions, regular knowledge transfer via weekly Skype meetings and more importantly, physical transfer of people. Dave Michalak is an Intel engineer in the Quantum Computing group and worked in Delft for the last two years, mainly with the superconducting team. Another Intel engineer, Kanwal Singh, is in Delft for one and a half year now and works together with us on the fabrication of spin qubits in purified silicon. In the other direction, I was given the opportunity to work at Intel last summer. I lived in Oregon for three months and mainly worked on low temperature characterization of transistors to help improve Intel-made spin qubit devices. I was able to act as a translator between the quantum people in Delft and the transistor people at Intel.

So far, Intel supplied us with purified silicon substrates, using a growth process that was completely new for Intel at the start of the collaboration. Giordano Scappucci's team set up fabrication and measurement capabilities that allow for fast turn around and quick feedback in order to improve material quality. This means that for our quantum dot device fabrication effort in Delft, we now have an essentially unlimited supply of high-quality material, in the form of 300 mm wafers. In addition, we have access to a set of metrology tools we could not have dreamt of a few years ago and Intel's processing experience is invaluable in solving the various issues we run into in the cleanroom. The Intel philosophy of 'copy exactly' facilitates well-thought decisions, but on the other hand doesn't lend itself well for quick tries. This is a delicate balance: to be able to draw firm conclusions you need to work systematically and take incremental steps, but sometimes it pays off to be bold and make more radical changes in an attempt to solve a problem. The first experimental result on quantum dots fabricated on Intel substrates is about to be published. It is a promising result showing only a weak temperature dependence of spin relaxation and charge noise. Naturally both sides of the collaboration are happy to see all the hard work pay off.

University-industry collaborations come with their own challenges. In the long term, I strongly believe our goals are aligned, but on the short term interests of academia and industry can be misaligned. What's interesting scientifically, isn't necessarily what an industry partner is after. PhD students and postdocs want to write a thesis and publish their results. That is not a priority for industry and sometimes even the opposite of what industry would like: keeping the results for themselves. With quantum computing's potential for commercialization, industry and academia will have to find the middle ground on these topics and we did. QuTech's researchers can publish their work, but whenever relevant a patent application will be filed prior to publication. Furthermore, not

all technical details of work done at Intel can be shared, since findings in Oregon can relate to Intel's core business and affect more than just the quantum program. Therefore, since PhD students and postdocs in Delft must be able to talk freely about their work with colleagues from all over the world, they themselves are not provided with all details.

To be able to make fast progress towards the grand goal of realizing a quantum computer, a multidisciplinary approach and strong collaboration between academia and industry are crucial. This is exactly the path we pursue at QuTech together with Intel and Microsoft. Working with industry is an interesting process, which comes with challenges, but also huge opportunities that make it extremely motivating to work in this environment.



From left to right: Kanwal Singh (Intel), Menno Veldhorst, Jelmer Boter and Gabriel Droulers (Kavli and QuTech) showing the first ^{28}Si-MOS wafer that arrived in Delft.