ALD and ALE for quantum computing

Short description: The aim of this project, within which multiple BEP and MEP projects are possible, is to establish atomic scale processing (ASP) techniques as key instruments for the fab-scale production of quantum technology devices. Atomic layer deposition (ALD) and etching (ALE) are ASP techniques with atomic-level control of the film thickness.

Background: To realize fault-tolerant large-scale quantum computers, major material advances are required. While for the past few decades the quantum community has largely focused on design optimization, it now becomes clear that material challenges limit the progress in quantum computing. Our aim is to help bridge this quantum-materials gap by adapting semiconductor industry approaches to quantum platforms. In this way, we want to establish ALD/ALE as key fabrication technologies in the quantum revolution.

In our research, we explore and optimize different materials and tune our ALD/ALE processes for quantum applications. The materials we prepare are tested in various quantum devices.

Below ('Project opportunities') are some general examples of BEP and MEP project possible within the ALD and ALE for quantum computing project. As the project is always progressing and new interesting challenges and opportunities come up, please contact us (see details below) to define a detailed project together. In these projects you will learn about ALD/ALE, become proficient in various characterization methods (e.g., XPS, XRD, SE, ...), and gain experience in working in a cleanroom facility.

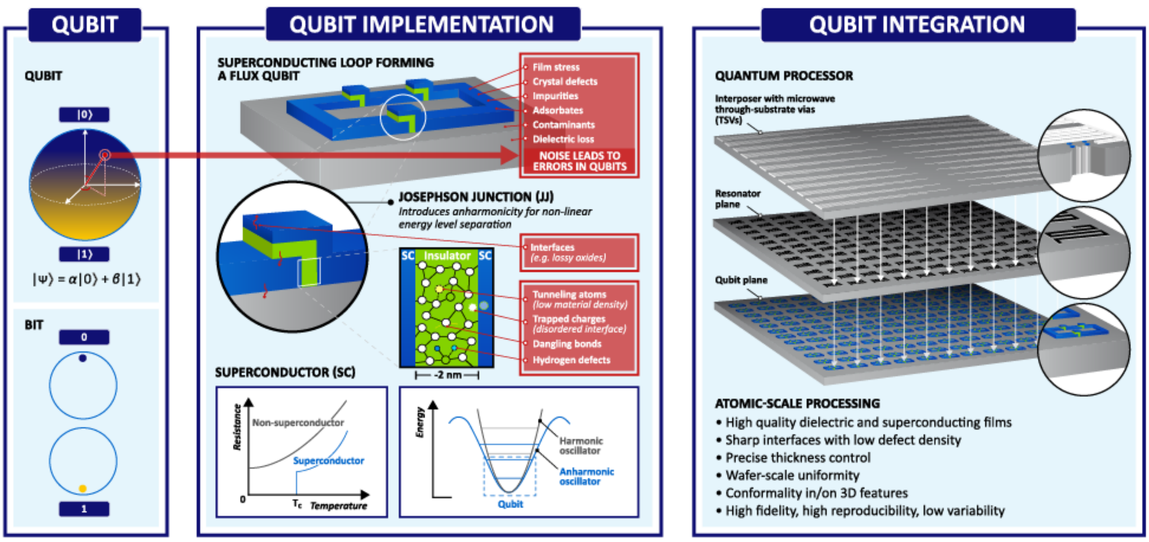

Fig. 1: *Overview of qubit implementation – how do we build a qubit? – and qubit integration – what other building blocks do we need for a quantum chip? Various material loss mechanisms limiting the development of large-scale quantum systems are shown, and the potential of ASP is highlighted. BEP/MEP projects can e.g. focus on improving the quality of superconductors and their interfaces, uncovering the importance of loss mechanisms, or optimizing conformality for TSV fabrication.*

Project opportunities:

- ALE of superconducting metal-nitrides: ALE has great potential to remove lossy surface oxides from superconducting metal-nitrides, decrease surface roughness, and controllably pattern superconductors.
- Ultrathin, high-quality dielectric layers: By combining ALD and ALE ultrathin dielectrics such as Al_2O_3 of high quality can be obtained. These films must be pinhole-free and highly uniform.
- Conformality study of PEALD superconducting nitrides: Conformality is a very powerful property of ALD, but becomes more difficult to attain when using a plasma. Conformal plasma-enhanced ALD (PEALD) is a highly-sought-after capability, for example for through-silicon-vias (TSVs) for quantum processors.
- Surface oxidation of PEALD superconducting metal-nitrides: Superconductor surface oxidation is very problematic for quantum applications. Research must be conducted to identify the degree of surface oxidation for various materials and environments, and subsequently minimize this through e.g. post-treatments.

If interested please contact:

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Location and supervision: You will perform experiments in the cleanroom that is located in the Spectrum building. You will be supervised by Silke/Guillaume and Harm.