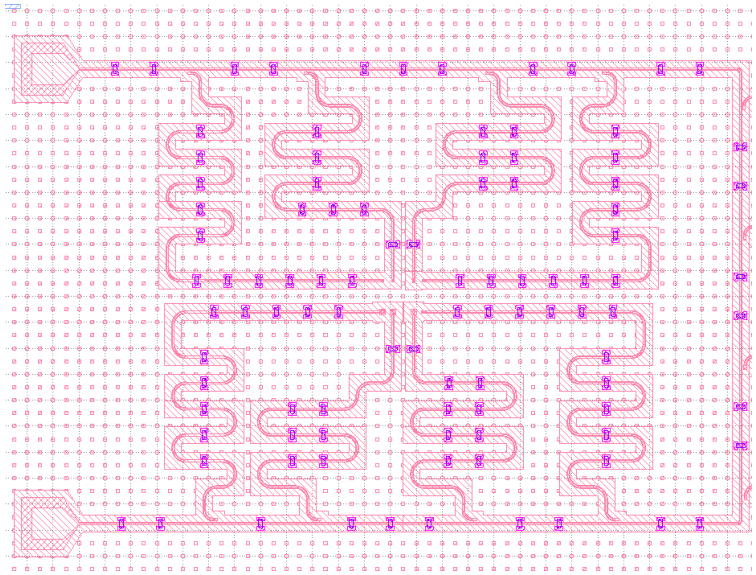
Making levitated microparticles *quantum* with the first coplanar waveguide (CPW) resonators fabricated in Leiden

Proposal student project at Hensen lab

Our lab addresses one of the key challenges of modern physics: understanding the interface between quantum mechanics and general relativity. Recently, an experimental test was proposed that can directly witness the need to unify the two theories: observing quantum entanglement between objects that only interact through the gravitational field [Bose et al., 2017]. A successful test would prove the existence of superpositions of space-time and have far-reaching implications on how we understand our world. We aim to develop and characterise an experimental platform that can be used for such a 'entanglement through gravity' experiment. The objectives of our research programme are to trap and levitate a picogram mass, cool its centre-of-mass motion to the quantum ground state, and measure a spatial superposition of the mass.



Because our approach is chip-based, we fabricate our samples in the cleanroom. Coplanar waveguide (CPW) resonators can be patterned in a layer of superconducting metal on top of a substrate (see image for a 10x5mm chip design with eight CPW resonators coupled to a feedline). CPW resonators play a key role in the cooling part of our research programme: we will use them to magnetically detect the motion of the levitated particle with very high precision. Knowing the particle motion, we can apply adequate feedback to slow it down (=lower its temperature).

CPW resonators are frequently used in quantum information processing architectures; they are for example used to read out qubit states. As of today, we have little experience in Leiden fabricating CPW resonators, but it would really boost our research if we could custom build CPW's ourselves. Together with us, you will work on setting up a reproducible fabrication process for high quality resonators. During this project, you will experience a full cycle: learning about CPW's theoretically, designing the chips, getting hands-on experience both in the cleanroom and the lab, where you will measure your resonators in a helium-based cryostat, evaluating the results, and planning the next cycle. We are a young and small research group, and you will be most welcome to learn about and get involved in our other research lines as well.

For questions, please contact: Stef Koenis (koenis@physics.leidenuniv.nl)