Workshop title: Cryogenic RF on-wafer S-parameter and noise measurements for quantum computing applications

Organiser: Xiaobang Shang, National Physical Laboratory (NPL), UK

Summary

Cryogenic RF on-wafer measurements of superconducting and semiconductor devices at 4 K are increasingly important for developing the control and readout architectures required for scalable quantum computing. This workshop will bring together leading perspectives from national metrology, instrumentation, and academic research to review recent progress in cryogenic on-wafer S-parameter and noise measurements. Through four talks - two focused on S-parameter measurements and two focused on noise and noise-parameter characterisation - attendees will gain a concise overview of the current state of the art, key practical challenges, and emerging solutions for accurate RF characterisation at cryogenic temperatures.

Speakers

Xiaobang Shang

National Physical Laboratory (NPL), UK

Talk title: On-wafer S-parameter measurements of planar circuits at 4 K

Abstract: This talk will review NPL’s work on on-wafer S-parameter measurements at 4 K. Topics will include improvements to, and adoption of, a cryogenic probe station; the design and characterisation of a bespoke calibration and verification wafer; and a recent interlaboratory comparison at 4 K using this wafer.

Gavin Fisher, **Beverly Boiko**, **James Hibbert**

FormFactor, Germany/US

Talk title: Overcoming RF measurement and positioning challenges at 4 K using piezo-driven stages

Abstract: This talk will discuss approaches for performing RF measurements at 4 K without the consumption of cryogens. We will show the capability to measure devices across wafers and impedance-standard substrates while avoiding the vibration typically associated with Gifford-McMahon cryogenic coolers. Probe positioning is achieved using piezo-motor-driven stages, which do not require external mechanical drives; however, these positioners present specific challenges at 4 K. We will demonstrate how optical error detection and

adjustment can minimise these errors. RF contact sensing is also used to optimise the contact cycle. Finally, we will show automated multiline thru-reflect-line (MLTRL) calibration results and active-device measurements at 4 K.

Mauro Marchetti

Maury Microwave, US

Talk title: Cryogenic impedance tuner for noise-parameter extraction

Abstract: This talk will present a four-state impedance tuner suitable for operation at 4 K that enables the extraction of noise parameters at cryogenic temperatures. The talk will cover the theory of cryogenic noise-parameter extraction and present practical examples of measurements performed at 4 K.

Chong Li

University of Glasgow, UK

Talk title: On-wafer cryogenic noise-parameter measurements: challenges and opportunities

Abstract: Low-noise amplifiers (LNAs) are critical components in the readout chains of quantum computing systems, where ultra-low-noise performance is essential. Accurate extraction of transistor noise parameters is fundamental to the design and optimisation of LNAs that can meet these demanding requirements. Although on-wafer noise-parameter measurements at room temperature are well established, accurate characterisation at cryogenic temperatures remains challenging because of the limited availability of impedance tuners capable of presenting the wide range of source-impedance states required for noise-parameter extraction. This talk will review the challenges associated with cryogenic on-wafer noise measurements and discuss emerging solutions, highlighting their advantages, limitations, and practical implementation considerations.