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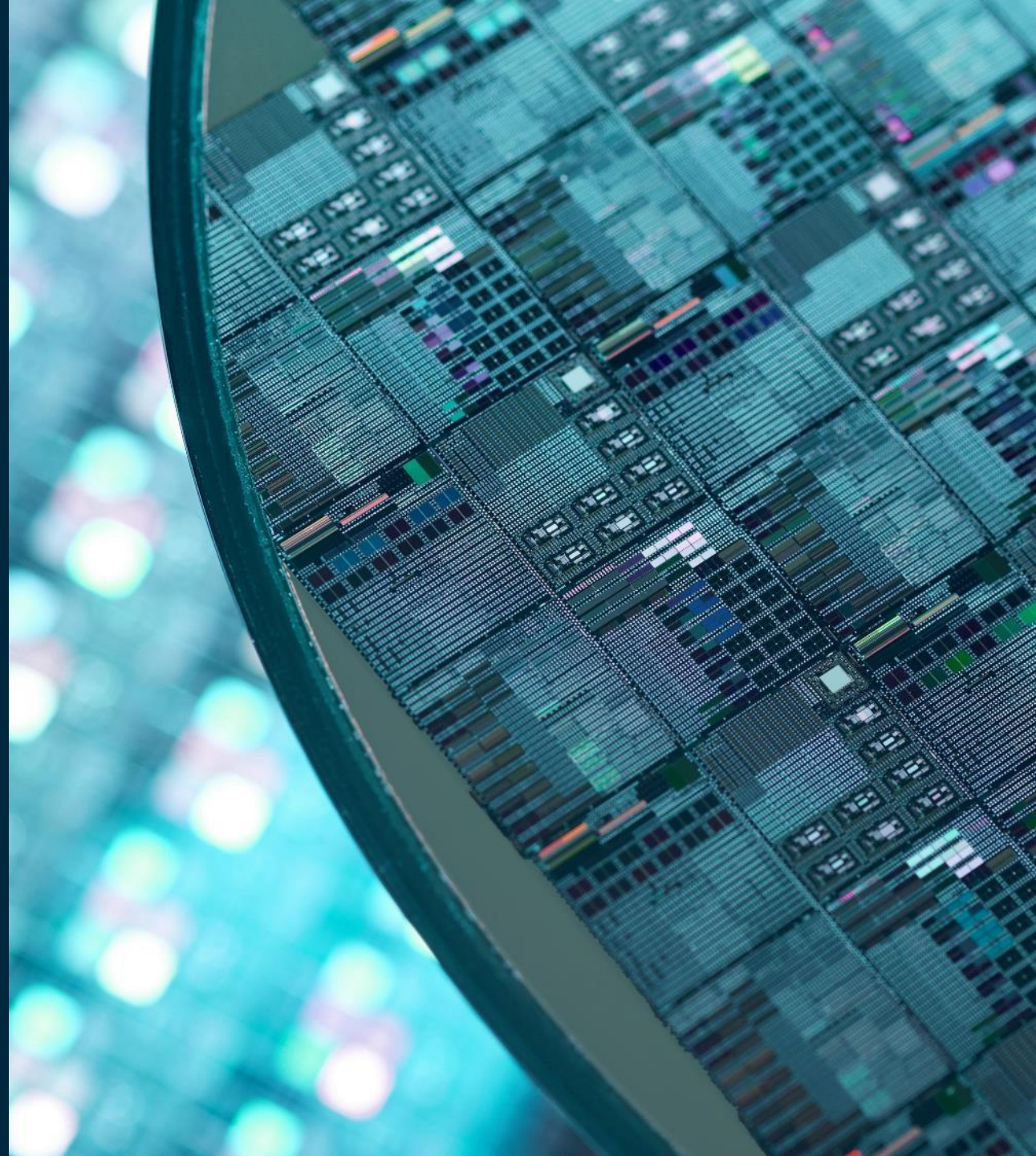
Exhibit Booth #8030

Strategies for Enabling Quantum Development with Test & Measurement from 77K down to milli-Kelvin

Jack DeGrave, PhD

Quantum Applications

THMA70



FormFactor At a Glance

WHO WE ARE

FORM NASDAQ SINCE 1993

LAST 12 MONTHS REVENUE

~$762M

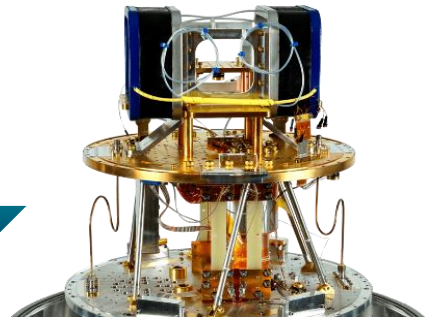
2,200+ PEOPLE

WHAT WE DO

CRYOGENIC TEST & MEASUREMENT

300K

50mK



PROBE SYSTEMS & PROBE CARDS

ENGINEERING & PRODUCTION

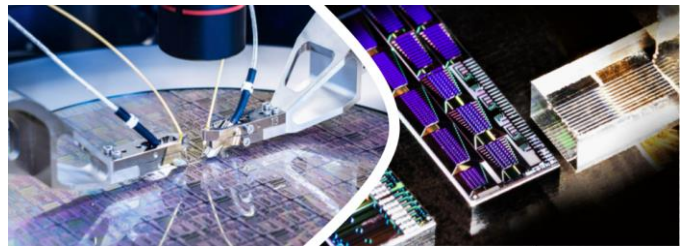
8,500+ LABS WORLDWIDE

TEST SERVICES

SUPERCONDUCTING DEVICES (4K, 50mK)

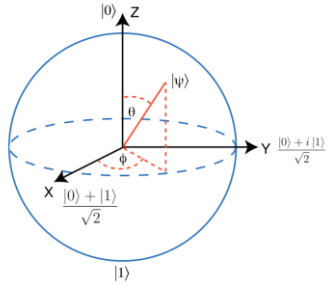
CMOS (4K, 77K) and COMPONENTS

PHOTONIC DEVICES (4K, 50mK)



Quantum Computing Market Introduction

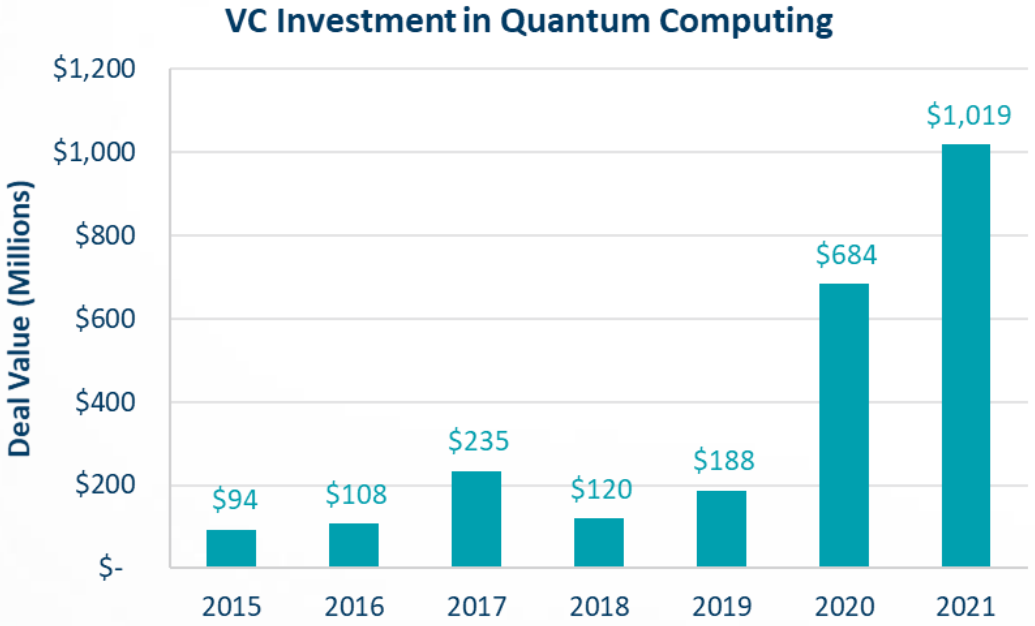
- Quantum computers are expected to solve problems that are unsolvable by classical computers
- Qubits instead of bits (superposition & entanglement)
- Application areas
  - Simulation of large molecules
  - Drug discovery
  - Financial modeling
  - Cybersecurity
  - And more…

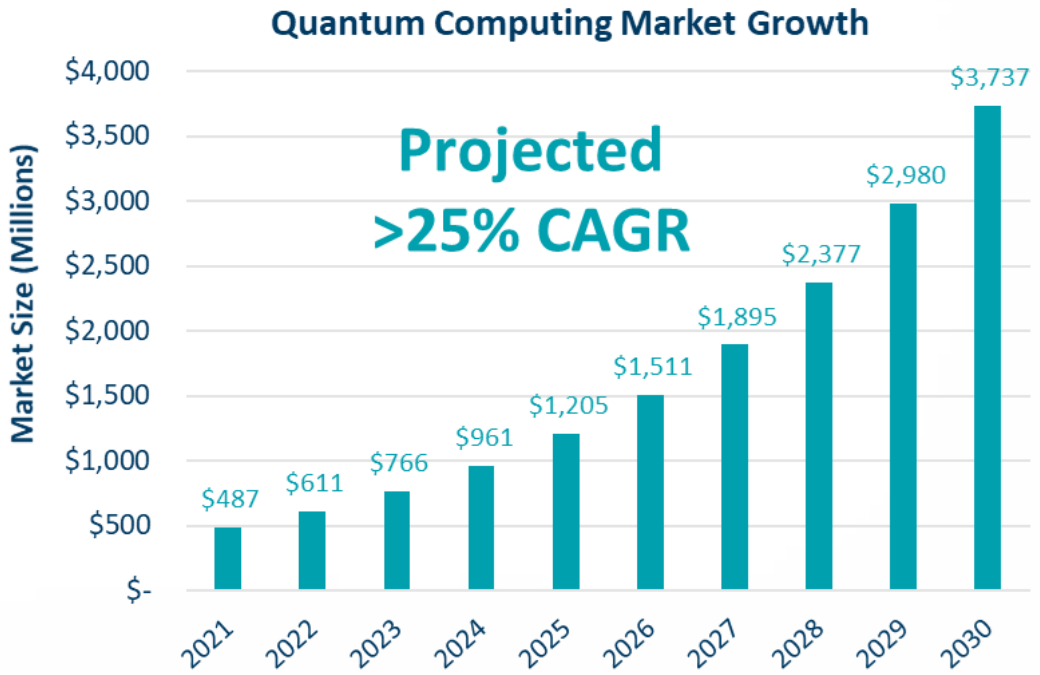


Publicly Traded QC Companies

IONQ rigetti D-Wave The Quantum Computing Company™

Announced Q1 2022





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Enabling Developers and Suppliers

Problem

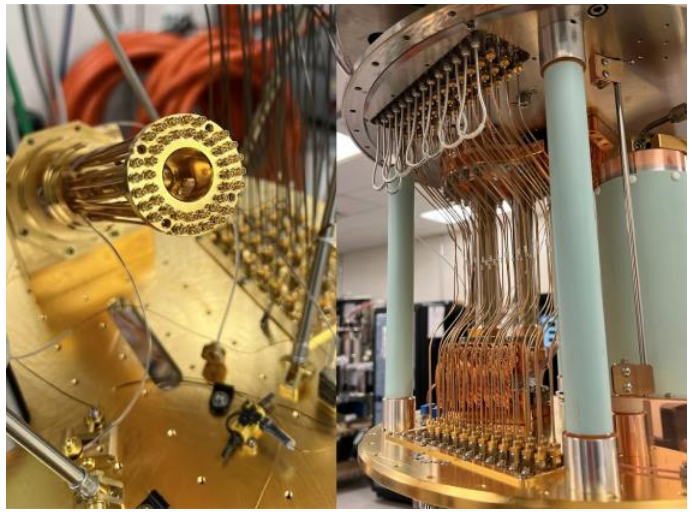
Cryogenic Test Equipment

High Capital Cost

Long lead time

- Limited Access to < 4 K and mK
- Slowed Development Cycles
- Poor Component Qualification

TEST SERVICE



Solution

Cryogenic Test &
Measurement as a Service

Immediate Cryogenic Access

- Reduce R&D Risk
- Learn Design for Test
- Eliminate Barrier to Entry
- Prepare to Scale

Cryogenic Test & Measurement Services

50mK

Chip & Component Testing
Model 106

< 50mK base temp

No wire bonding

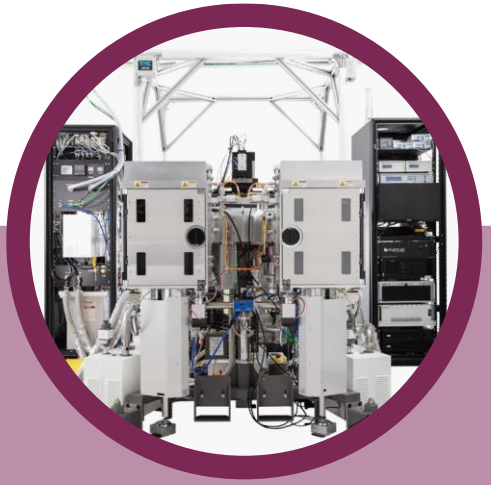
Up to 24 RF (< 12 GHz)

48 shielded twisted pairs

Probe socket

4K

2K



Wafer Testing
IQ3000

< 4K, < 2K wafer probing

200mm wafers

Magnetic shielding (< 200nT)

56 RF and >500 DC

Probe cards

Accelerate QC Time-to-Data by 10X

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Accelerate Quantum Development

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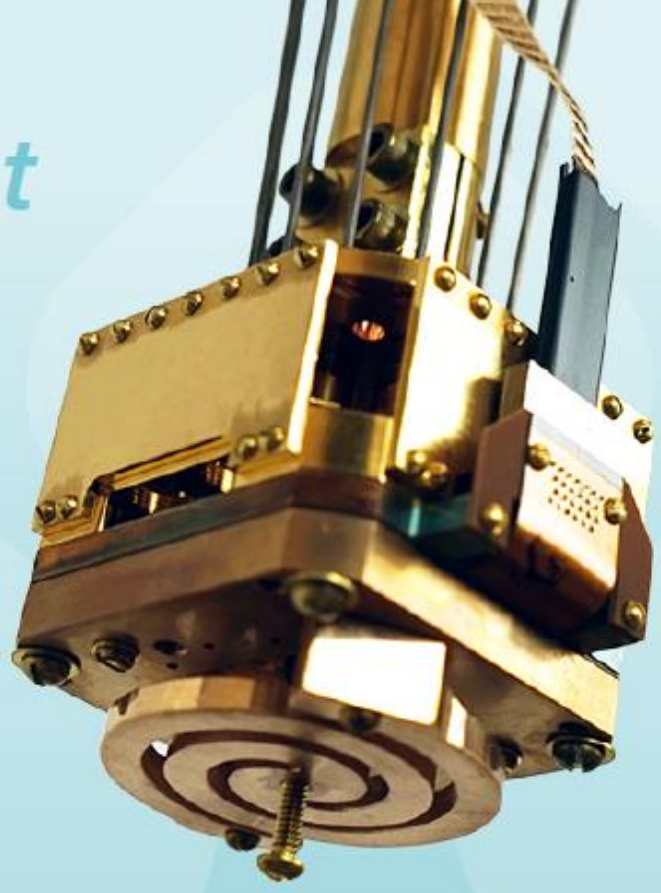
Booth #8030 for details



Advanced Cryogenic Lab

GRAND OPENING | DINNER AND TOUR

50mK

50 mK ADR Cryostat

Chip-Scale and Component Test Solution

Use Cases

Developers

Qubit & Resonator Pre-characterization

Process Control

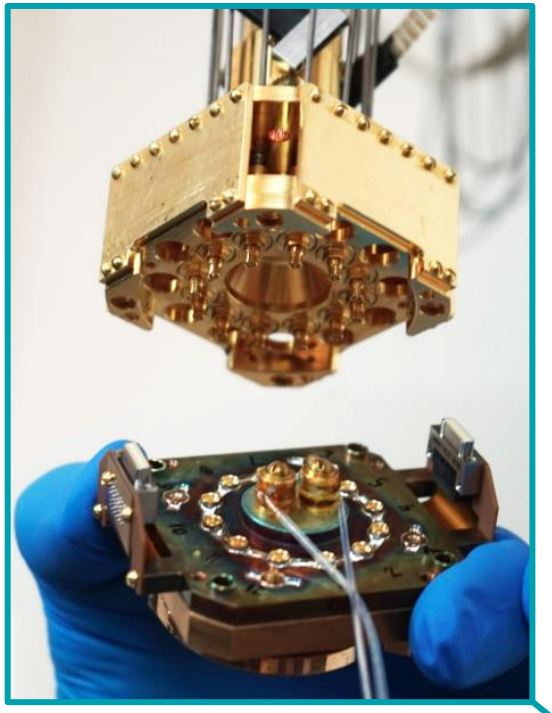
Materials Development

Vendors

Component Qualification

Performance Validation

PQ500 Probe Socket



Model 106 ADR Cryostat

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4K

2K

Photonic, Superconducting & Spin Qubits

Wafer Prober Solution for < 4 K, < 2 K

Use Cases

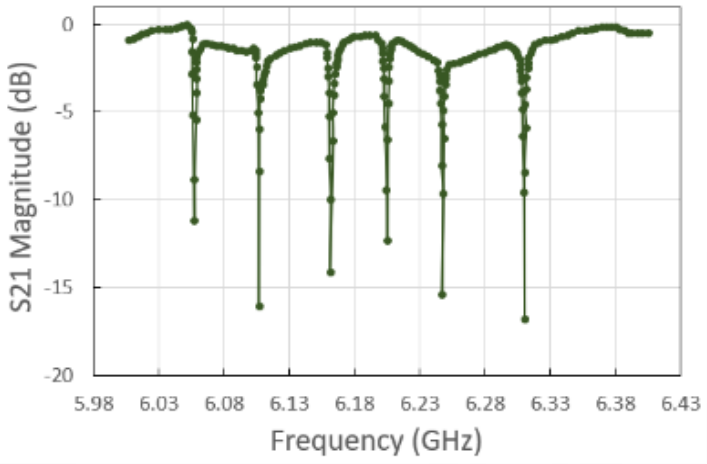
Statistical process control for scaling

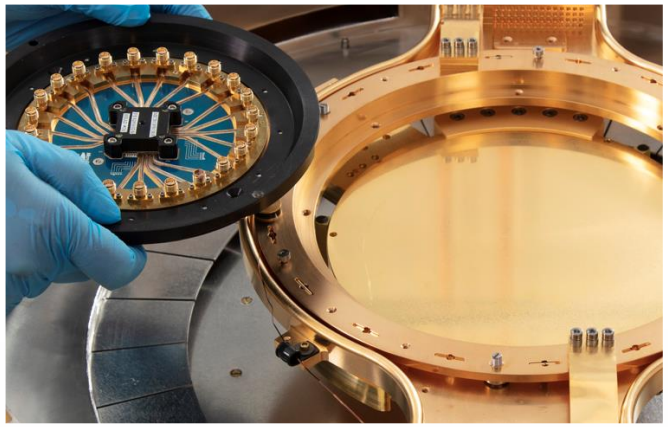
4 K Nb resonators (S_{11} & S_{21})

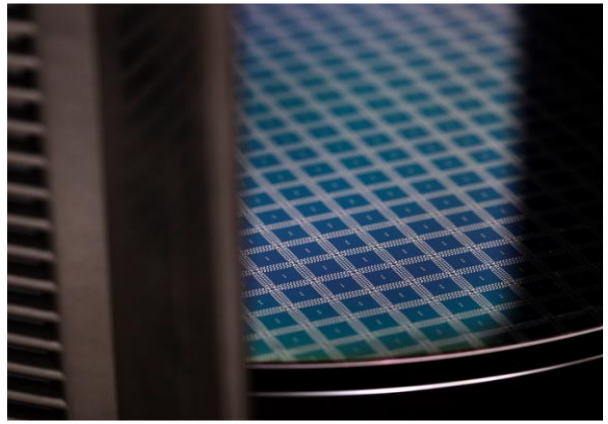
Josephson-Junction resistance

Machine learning models for qubit diagnostics

IQ3000 Cryogenic Wafer Prober







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HPD

4K Cryogenic Wafer Prober

Fully automated cryogenic wafer probing at 4K

Cryogen Control

- Warm Water Bath
- Vacuum pump with flow controller and pressure regulator
- Recirculation with Binary Gas Analyzer and a 3-way directional valve

Vision System

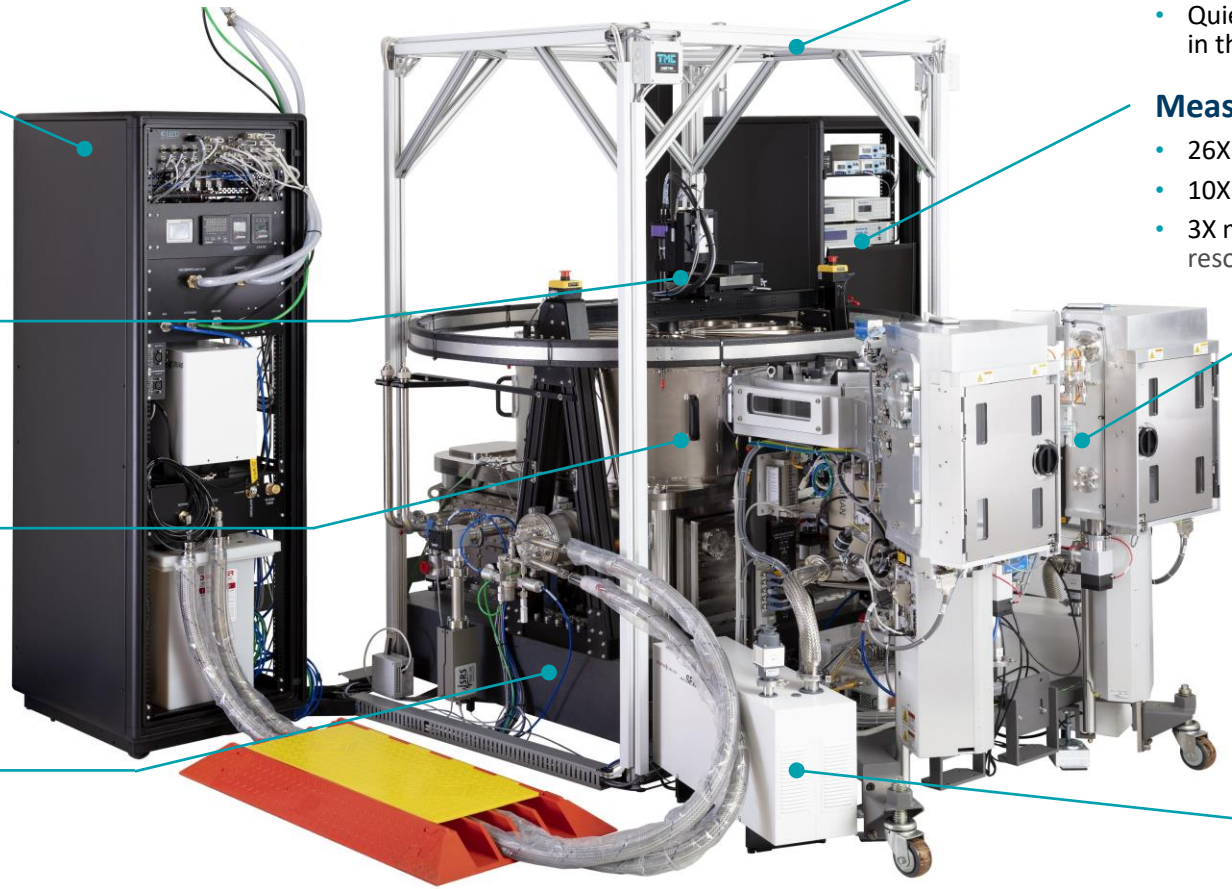
- 50 mm XYZ Travel
- <3 um resolving power
- Pneumatic lift and rotatable beam for easy servicing

Probe Station

- Gas spring assisted vacuum lid and latchable shield lids
- <4.5 K with 44 RF probes in contact
- +/- 112 mm XY, 0 – 13 mm Z, +/- 10° Theta motion

Rigid Construction

- A solid granite base with a rigid motion structure
- Allows for rapid die to die movement and fast settling times
- Up to 25 mm/s travel speed



Magnetic Cancellation

- Active cancellation with passive cryogenic shielding
- Quiescent magnetic field environment of <200 nT in the 4 K wafer space

Measurement and Control Electronics

- 26X system thermometers
- 10X 50 W heaters for rapid warmup in <8 hrs
- 3X magnetic probes with 0-200 uT range and 1 nT resolution

Wafer Cassette Loader

- Automated loading for 200 mm and 150 mm wafers
- Up to 25 wafer capacity
- <15 minute exchange time between wafers

Vacuum Feedthroughs (Not Shown)

- Two large configurable vacuum flanges with additional smaller ports
- Large ports are 12 in x 18 in and 12 in x 26 in
- Base 56 RF (18 GHz) and 520 DC

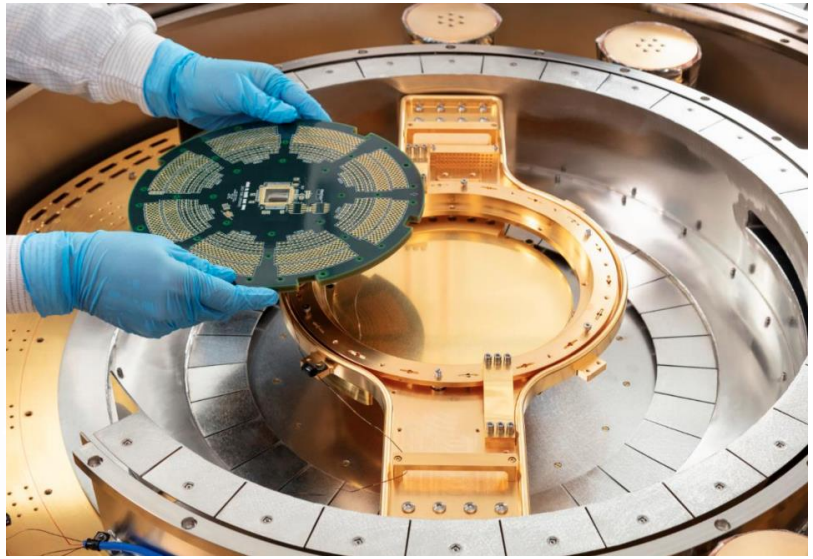
Automated Pumping System

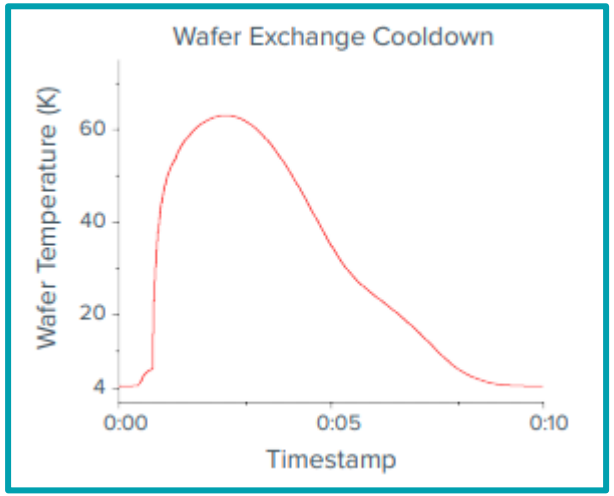
- Load lock isolated pumping systems for wafer loading while system is at base
- Full system pump down in <40 minutes

4K

IQ3000 – Cryogenic Wafer Prober Details

Probe card installation

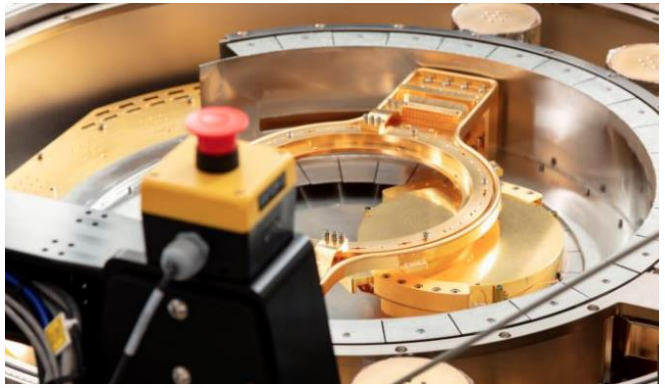




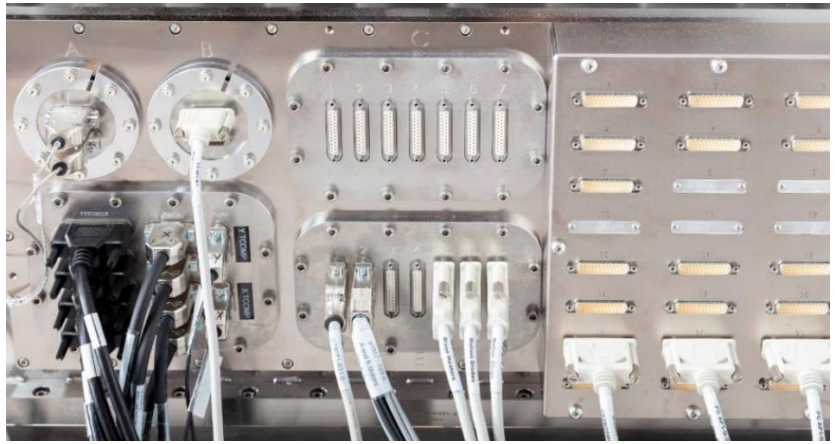
RF Feedthroughs

Wafer under probe card fixture

Chuck without wafer



Operational and DC feedthroughs



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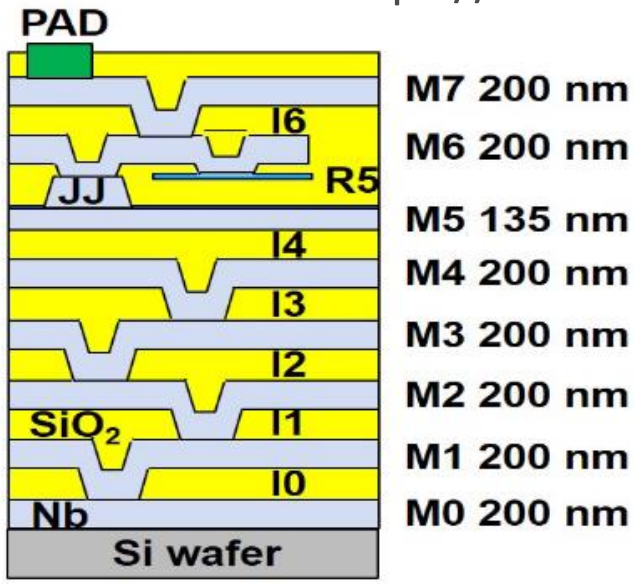
SFQ Device Characterization at 4K

of Devices = 24 SQUID-based Test Circuits

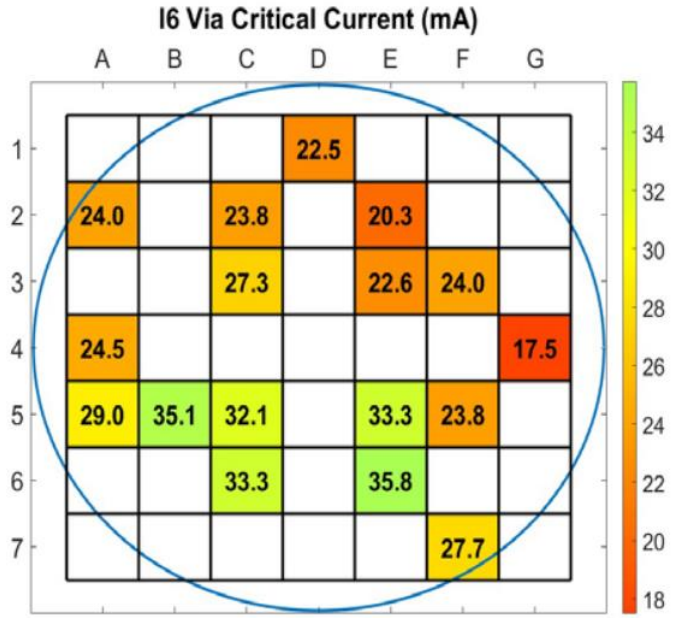
Test Method	Time to Measure at 4K
Conventional singulated die testing (dicing, wire bonding)	**> 1 week**
IQ3000 4K Cryogenic Wafer Prober with 200mm wafer	**5 hours**

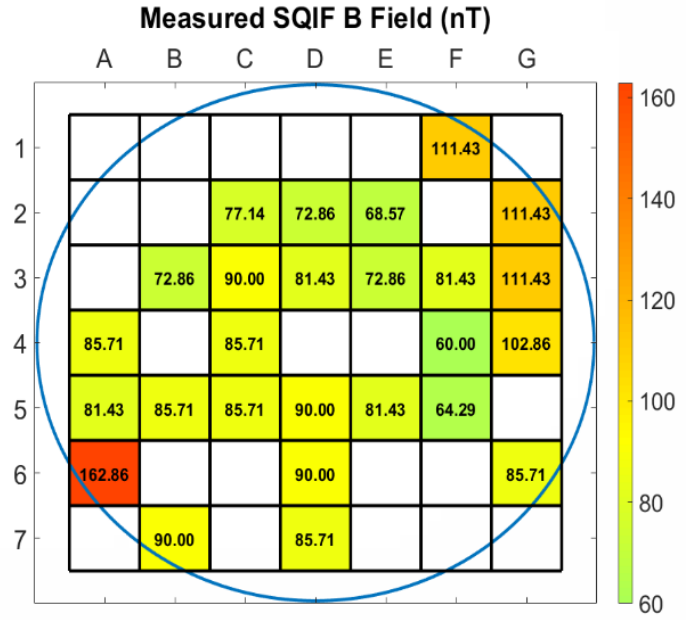
https://arxiv.org/abs/2112.00705



Characterization Measurements

1. SQUIF B field
2. Inductance/unit length
3. JJ critical current
4. Normal resistance
5. Gap current (V_g)





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MASSACHUSETTS INSTITUTE OF TECHNOLOGY

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