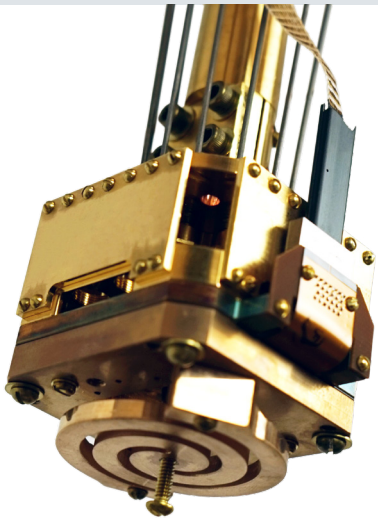


# HPD
# Cryogenic Test & Measurement Lab

FormFactor Test Services

FormFactor™

## Rapid Access to Cryogenic Temperatures to Boost Quantum Research and Improve Device Yield

Cryogenic systems are a major investment. Long waits for data can slow down development cycles and hinder production schedules. Cryogenic test services allow you to avoid the high upfront capital cost of a complete system, enable immediate access to cryogenic data, and ensure you are obtaining the data you need to advance your program.

Join us at the Cryogenic Test Lab, located in Boulder, Colorado, where you can partner with FormFactor to build custom probing solutions and collect the valuable cryogenic data you need. Whether it's at 4 K or < 50 mK, we will work with you to solve your unique test and measurement challenges.

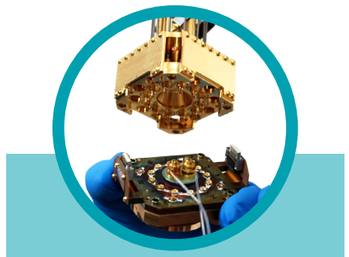
**How can we help enable your technology?**

- Screen for manufacturing defects at cryogenic temperatures to improve device sorting
- Statistically correlate room temperature data with cryogenic performance by obtaining high volume data at the wafer scale
- Pre-characterize Qubits prior to deployment to reduce QPU bring-up time
- Material characterization of superconducting devices

## What We Offer

Collect high volume data with our Cryogenic Wafer Scale Probe Station, or qualify your devices near deployment conditions with our < 50 mK ADR* Cryostats.

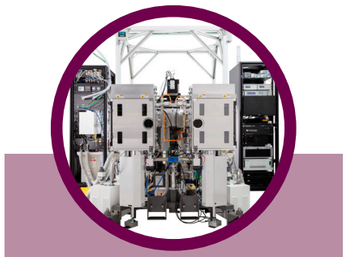
Each of our test packages leverages FormFactor's longstanding probing expertise and decades of precision cryogenic systems experience. We develop custom probing solutions for each system to eliminate the need for wire bonding. Materials are carefully selected to function in cryogenic and non-magnetic environments.



### Qubit Pre-Test

Model 106 & PQ500

- **< 50 mK base temp**
- 10 mm Singulated die test
- No wire bonding
- Up to 12 RF (< 12 GHz)
- 48 shielded twisted pairs
- Probe socket



### Wafer Testing

IQ3000

- **< 4.5 K wafer probing**
- 200 mm wafer
- 300 mm wafer fragment
- Magnetic shielding (< 200 nT)
- 56 RF and > 300 DC
- Probe cards

*ADR stands for Adiabatic Demagnetization Refrigerator. It is a solid-state method for reaching millikelvin temperatures using paramagnetic salts.

## How it Works

We will walk you through a four-step process to define and build the right cryogenic probing solution and to ensure a smooth test day. The full test service process may take as little as 4 weeks depending on the complexity of the probing solution. We are committed to working closely with you to provide the fastest time to data.

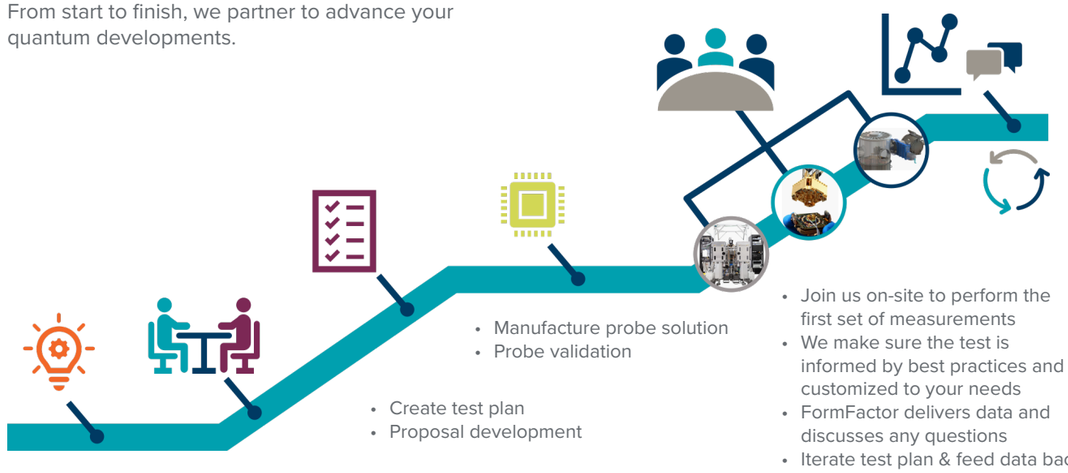
The four steps in our test services process are feasibility, quotation, preparation, and implementation. During the first phase we will work with you to understand the challenges and recommend the proper solution. In the second phase we will define a probing solution, configure the experiment, and develop a test plan. At this point a proposal is generated and submitted. Once accepted, a test date is reserved, and preparation begins. We will manufacture, set up, and evaluate your probing solution prior to the test date.

On the week of the scheduled test service date there will be a set up day prior to the first test day. We will initialize the system so that it is at base temperature and ready for measurements. You can choose to arrive on the setup day to validate the experiment, or you can arrive on the first scheduled test day and the system will be ready for testing as soon as you arrive. A test engineer will be present during your visit to operate the system and assist in test set up and data collection.



## Test Services at a Glance

From start to finish, we partner to advance your quantum developments.



- Start with an idea
- Select a path

- We work with you to explore your goals
- Define probing solution
- Select test equipment

- Create test plan
- Proposal development

- Manufacture probe solution
- Probe validation

- Join us on-site to perform the first set of measurements
- We make sure the test is informed by best practices and customized to your needs
- FormFactor delivers data and discusses any questions
- Iterate test plan & feed data back into your development program

1

## Feasibility

You may come to us with an idea or a vision of what you are trying to accomplish. Or we may help you uncover what that vision is. Our goal during this step is to understand what value cryogenic test services can provide and to help you choose the right test and measurement plan.

To kickoff this step we will hold a meeting to introduce you to the test services team and your point of contact. We will cover the full process and answer any questions you may have. The purpose of the technical meeting is to help us understand what your unique requirements are so that we can suggest the best service package and probing solution.

| What we do | What we need from you |
|---|---|
| • Schedule and hold a kickoff meeting<br>• Facilitate the signing of a mutual NDA<br>• Schedule and hold a technical exchange meeting<br>• Make recommendations on the best test service package to pursue | • A signed mutual NDA<br>• Technical information about the sample and types of measurements<br>• A selection of which test services package to define |



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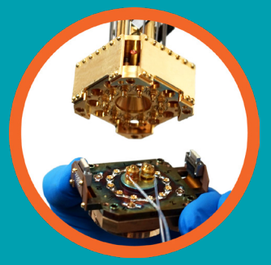
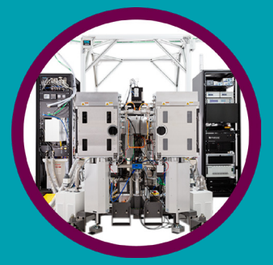
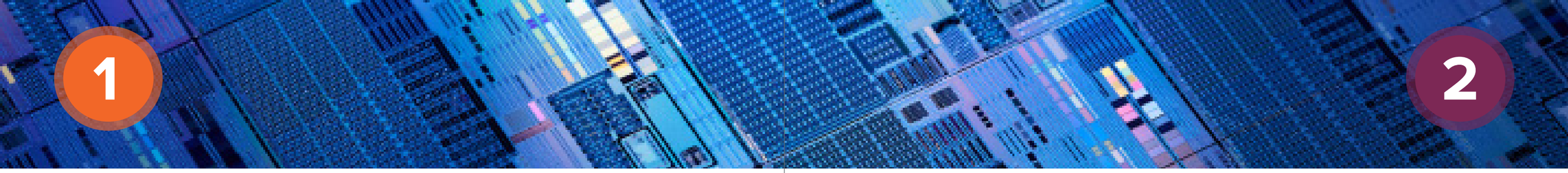
## Picking the Right Package

| Specification |  Qubit Pre-Testing |  Wafer Testing |
|---|---|---|
| **Sample Size** | 5 mm, 10 mm | 150 mm, 200 mm |
| **Temperatures** | 50 mK | 4 K, 77 K, 300 K |
| **Thermal Exchange Time** | 24 hours | 15 minutes |
| **DC Count** | 48 twisted pair | 288 twisted pairs |
| **RF Count** | 12 (18 GHz) | 56 (18 GHz) |
| **Fiber Count** | N/A | N/A |
| **Compatible Probes** | PQ500 | DCQ, ACP, Cantilever, MEMS |



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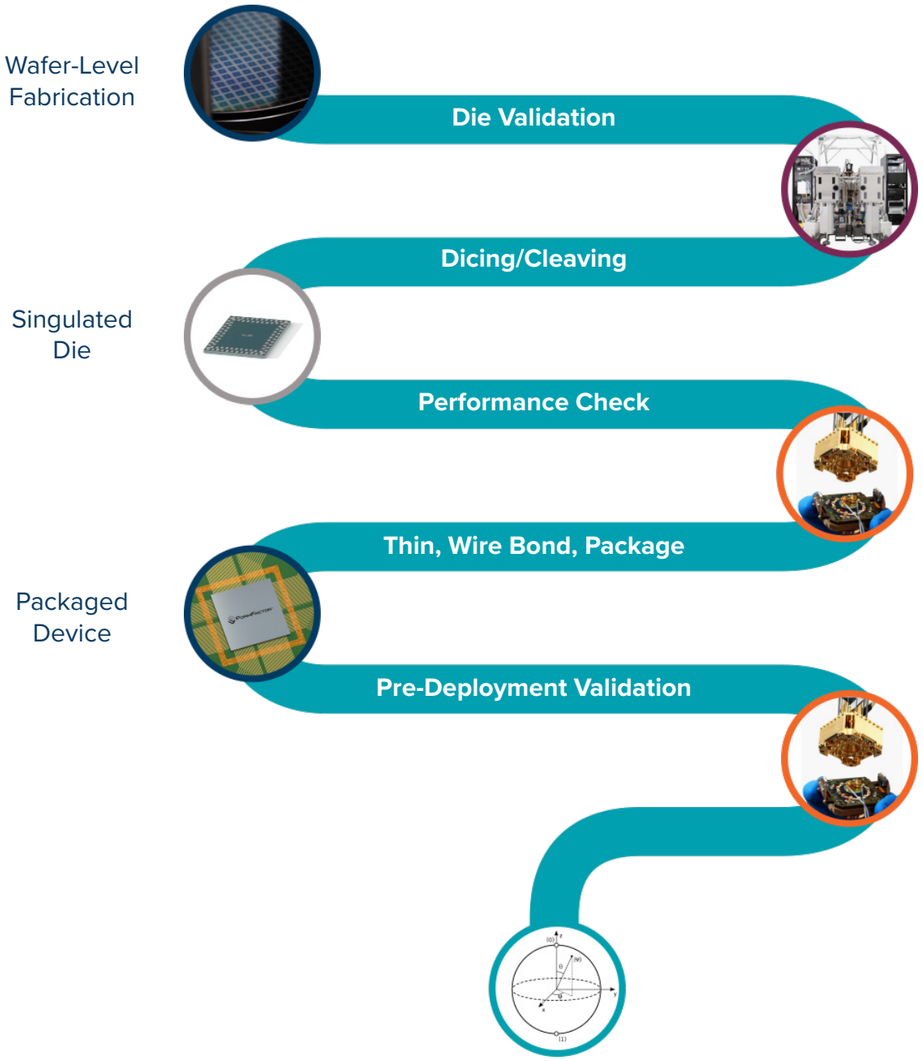
## With You Every Step of the Way

Regardless of where in your manufacturing process, wafer to packaged device. No matter the temperature, 300 K to 50 mK. We have a test and measurement solution for you.





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## Quotation

Once a package is selected, we can begin defining in more detail how the test will be performed. During this step we will define the probing solution, explore available add-ons, and generate a test plan. Next, we will build out a proposal based on this information, and we can review it together.

Depending on the selected package and the test requirements we will find the right probing solution. We offer an array of cryogenic probing solutions including fast turnaround engineering probes, wafer scale cantilever probe cards, and MEMS probe heads for high density probing.

| What we do | What we need from you |
|---|---|
| • Define the probing solution<br>• Provide a test equipment library<br>• Provide software ICD†<br>• Generates and submits a proposal based on requirements and selections<br>• Schedule and hold a proposal meeting to review probing solution, test plan, and costs | • Pad layout, dimensions, and material<br>• RF performance requirement<br>• Test equipment selection (or opt to bring your own*)<br>• Selection of options and add-ons<br>• Submit a PO |

*If you opt to bring your own test equipment you will be responsible for scripting the experiment. We will provide the ICD to our systems software if this option is selected.

†Only if opted out of the scripting service

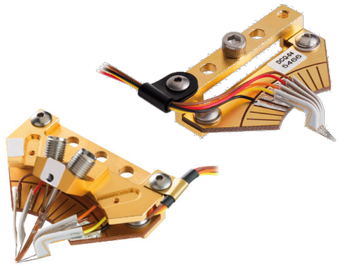
# Cryogenic Probing

Choosing the right probe solution is a crucial step in the Quotation phase. Depending on the complexity of the probe and the uniqueness of the requirements the cost and lead-time can change significantly.

We offer a wide range of cryogenic probe solutions and we are constantly adding more solutions to the catalog. Engineering probes have the fastest turnaround and are primarily used in the wafer prober. Probe cards provide larger signal count but are limited to the wafer probe system. Probe sockets offer the most flexibility for unique pad layouts including grid arrays.

## Engineering Probes

Engineering probes are great for quick turnaround and offer the fastest time to data. The ACP and DCQ are multi-contact probes for uniform or non-uniform pad layouts. These can be manufactured to your specifications in as little as 2 weeks. These probes are compatible with the Wafer Prober by using a Quad Card.



| | Number of Probes | Pad Min Size and Pitch | Pad Materials | Max DC Current | Max Frequency |
|---|---|---|---|---|---|
| **DCQ** | 24 DC | 50 µm²/100 µm | Al, Au, Cu, Nb* | 500 mA | 500 MHz |
| **ACP** | 3 RF, 9 DC | 80 µm²/100 µm | Al, Au, Cu | 5 A | 110 GHz |

*Niobium probing is currently being characterized at cryogenic temperatures

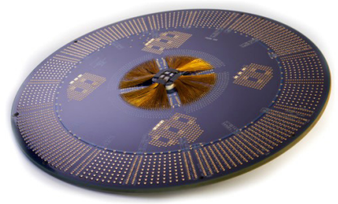




## Probe Cards

Probe cards are designed to interface with the wafer scale probe system. This solution allows for simultaneous testing of a full die.

Cantilever probe cards are less expensive and offer more flexibility with pad layouts. The Sonoma probe uses a MEMS process to manufacture precision probe tips for high density devices



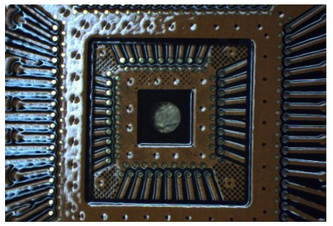
| | Number of Probes | Pad Min Size and Pitch | Pad Materials | Max DC Current | Max Frequency |
|---|---|---|---|---|---|
| **Cantilever** | 200 DC | 40 µm²/45 µm | Al, Au, Cu, Nb* | 500 mA | 3 GHz |
| **MEMS** | 200 DC | 30 µm²/40 µm | Al, Au, Cu, Nb* | 500 mA | > 12.5 GHz |

*Niobium probing is currently being characterized at cryogenic temperatures

## Probe Socket

Vertical probe sockets provide ultimate flexibility in pad layout. These probes can be used in the Qubit Pre-Test package.

The PQ500 is a chip socket that can support up to 10 mm chips. It uses high-performance circuit and probe design to achieve your RF requirements.



| | Number of Probes | Pad Min Size and Pitch† | Pad Materials | Max DC Current | Max Frequency |
|---|---|---|---|---|---|
| **PQ500** | 200 DC, 12 RF | 250 µm²/400 µm | Au, Cu | 500 mA | > 12.5 GHz |

## Customize Your Package

We want to make sure that your test service package is right for you. We offer some options and add-ons and a library of test equipment for you to choose from. You are welcome to bring your own test equipment and for a small fee we will build the test cables to interface with our system.

You will be responsible for scripting your experiment. We will provide the necessary interface documents. Alternatively, we do offer a scripting service for an additional cost.

If you have customizations in mind and you don't see an option here, let us know. We are open to working with you to create the best solution possible.

## Preparation

After acceptance of the proposal, we will begin manufacturing the probe solutions and preparing for the test day. During this period, we will perform validation tests for custom probes and calibrate and align equipment in advance.

You will need to provide the sample (or test coupon) to be validated as well as any source/measurement equipment required for data acquisition. We perform thorough validation testing to ensure everything runs smoothly when you arrive on the scheduled test day.

| What we do | What we need from you |
|---|---|
| • Manufacture the probing solution<br>• Validate probe solution<br>• System preparation and alignment | • Sample(s) to be tested<br>• Test equipment (if opted to bring your own)<br>• Test script† |

†Only if opted out of the scripting service

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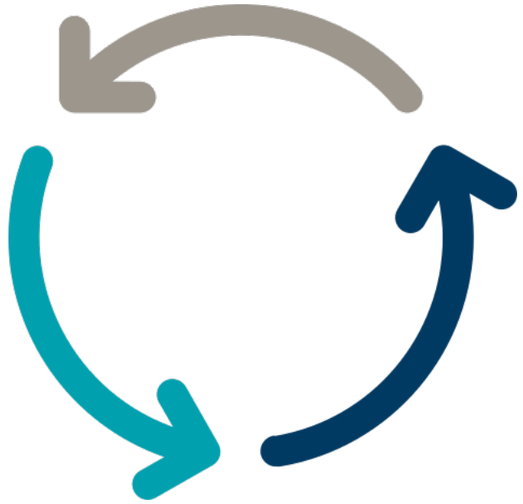
## Implementation

Join us for your first scheduled test days to conduct the tests and collect your vital data. You will have full access to the system with assistance from a test engineer to help operate and collect data. The day prior to your schedule arrival we will initiate the cool down so that you can collect data immediately when you arrive.

Upon completion of the measurements your data will be packaged and delivered to you in the format that you choose. After the first scheduled test repeat tests of the same solution can be implemented for a fraction of the cost. Your custom probe solution is yours to take with you, or we can hold on to it for future test services. We do not require you to be on site for repeat tests. Just send us the sample and we will send you the data. You are always welcome to visit though!



| What we do | What we need from you |
|---|---|
| • Set up experiment the day before the scheduled test day<br>• Pump down and cool the system<br>• A test engineer will be present during your visit to assist with the operation of the system. | • Arrive at our facility on the scheduled test day(s) |



## Contact Us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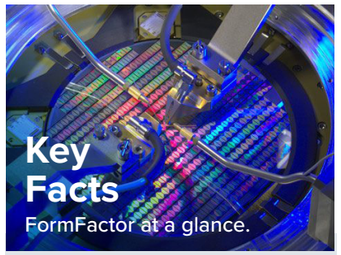
## FormFactor, Inc.

FormFactor, Inc. (NASDAQ:FORM) is a leading provider of essential test and measurement technologies along the full IC life cycle – from characterization, modeling, reliability, and design de-bug, to qualification and production test.


/ We strive to help our customers solve advanced test and measurement challenges

/ Our focus on customer partnership, innovation, agility and operational excellence allows us to earn sustainable business every day




/ Founded in 1993, IPO 2003

/ #1 Advanced Probe Card and Engineering Probe Systems Supplier

/ Named as a BEST Supplier in customer satisfaction surveys, year-after-year


/ Enable customer success through technology, partnerships, “First Time Right” product quality, global customer support

/ 2300 employees, with >500 directly supporting customers

BR-HPDTEST-0323