



Webinar: Integrated Probe Card Solutions for Magnetic Testing



Tom King, PhD
Lead Magnet
Scientist
GMW Associates



Karen Armendariz
CEO
Celadon Systems



Bill Funk
Chief Technical
Officer
Celadon Systems



Agenda

- Celadon On-Wafer Probe Solutions and Integration for Magnetic Testing
Presented by Karen Amendariz, Celadon Systems
- Spintronic On-Wafer Testing: An Integrated Solution
Presented by Tom King, GMW Associates
- Questions and Answers
Karen Amendariz and Bill Funk of Celadon Systems, Tom King of GMW Associates



CELADONTM

Ultra High Performance Probe Cards



GMW – CELADON INTEGRATION WEBINAR

KAREN ARMENDARIZ

August 25th, 2020

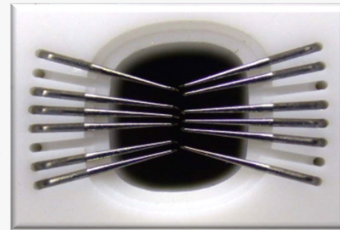
CELADONTM

CELADON SYSTEMS – KNOWN FOR INNOVATIVE ON-WAFER PROBE SOLUTIONS IN EXTREME ENVIRONMENTS



- Celadon has been in business 23 years. Celadon products are used by ~90% of semiconductor companies worldwide in addition to other applications like medical, space and defense.
- Celadon is a US based company: All of our engineering, manufacturing and repair is done in Burnsville, Minnesota.
- Celadon has a support center for PMs in Taiwan.

- Celadon's core competencies:
Probe cards, Cables and Adaptors
- Technology: **Advanced Cantilever**
- Celadon's core values:
Integrity, Innovation, Invention, Dedication
- Celadon has 57 Patents and 15 Pending Patents.



THREE IMPORTANT FACTS TO REMEMBER ABOUT CELADON SYSTEMS



I - Technology: **ADVANCED CANTILEVER**

=> Near Vertical, 0-9 degrees, with a “**tunable scrub**”

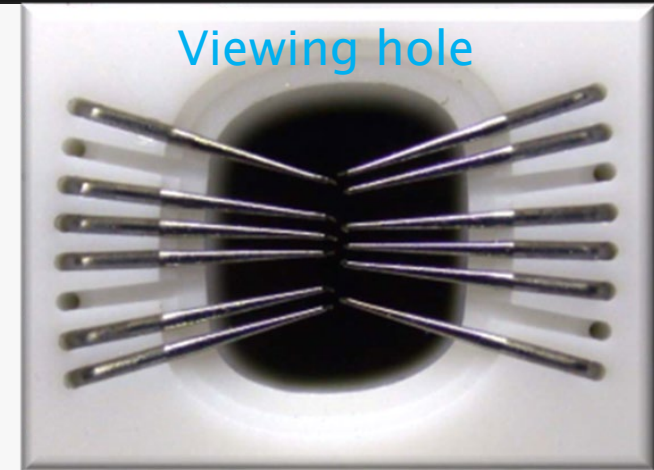
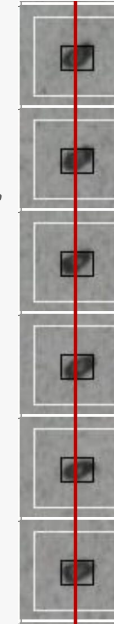
=> Controlled scrub mark and gram force

Our Advanced Cantilever offers customers the *BEST OF BOTH WORLDS*

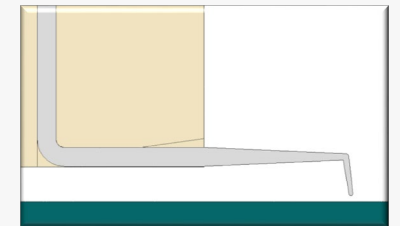
- Cantilever Technology:
 - Familiar technology, operators aren’t afraid of it
 - Learning curve is short
 - Probe marks are visible
 - Rebuildable and Repairable

What is “ADVANCED” about our technology?

- The ability to probe very fine features due to our “tunable scrub” and our automated manufacturing processes with tight tolerances:
 - » Our Production customers are probing 25 micron pads successfully at room temperature
 - » Using the same card, our Lab customers are probing from -65C to 200C on ~30 micron pads.
- Low Leakage, our goal is to be invisible in your set up, offering products with less than 1fA.



One piece probe



Uniform beams

THREE IMPORTANT FACTS ABOUT CELADON SYSTEMS



II - Celadon's patented Crash Resistant Probe in Ceramic Technology™ results in FEW rebuilds and alignments over the cards lifetime:

Celadon has a different model, we don't have repair centers all over the world, because we haven't needed them. We have one Repair Center located in Minnesota. Our cards are extremely durable and robust.

- In total, Celadon only rebuilds about 25 cards a month for ALL territories with tens of thousands of active cards in the field.
- Most failures are handling related or occasionally due to a burnt pin versus being worn out.



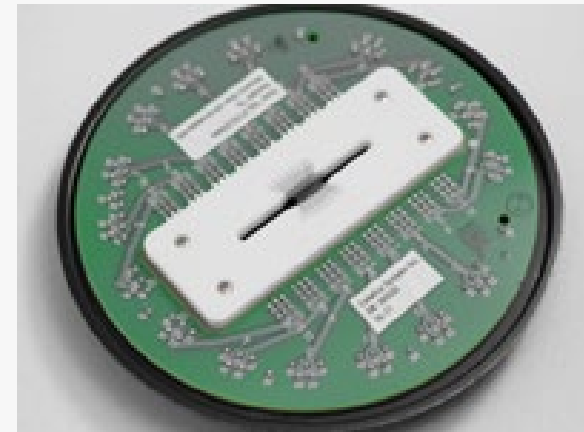
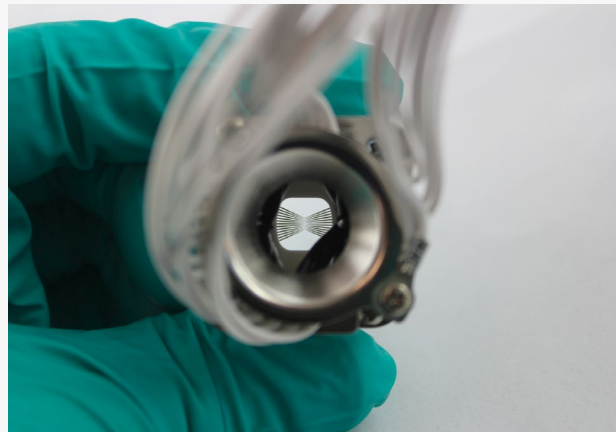
We at Celadon are very serious about our probe card's durability. If you are interested in seeing how robust our cards are, we have some informative and entertaining videos online at www.celadonsystems.com demonstrating what happens when a Celadon card is crashed into a wafer, ran over, blown up, grilled, frozen or washed in a dishwasher - we simply brush the probes off using a Celadon toothbrush and start probing again. We hope you check out our videos!

THREE IMPORTANT FACTS ABOUT CELADON SYSTEMS



III - Exceptionally Long Life - If you take care of your probe cards, you can expect millions of touch downs whether you are in the LAB, FAB or on the TEST FLOOR.

- ❖ *Celadon Systems and Freescale Corp/NXP published a joint technical paper five years ago at SW Test on exceptional lifetime performance. At that time, they had achieved 13 million TDs using Celadon's VC20™.*
- ❖ *Customers have reported over 20 million touch downs on their probe cards. To prevent unplanned failures, most of our production customers intentionally rebuild at 10 million touch downs.*



Celadon's goal for you is *Peace of Mind Probing* - we want your cards to work as intended, so they aren't "top of mind", so you can focus on other things.

CELADON'S MARKET FOCUS

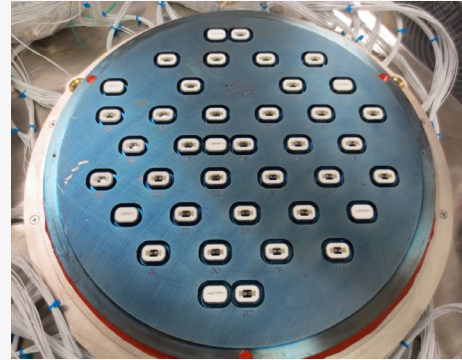


Modeling and Characterization

Device Labs

Modeling Labs

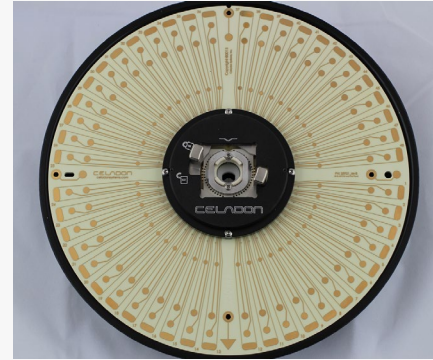
Characterization Labs



Wafer Level Reliability

Reliability and Burn-In Labs

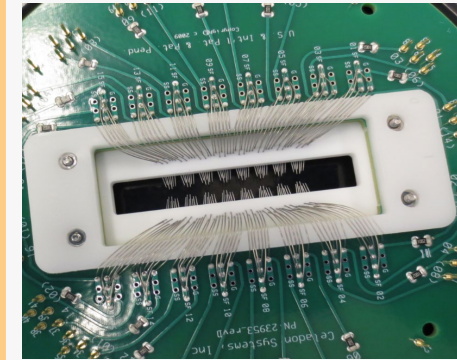
High Volume Manufacturing



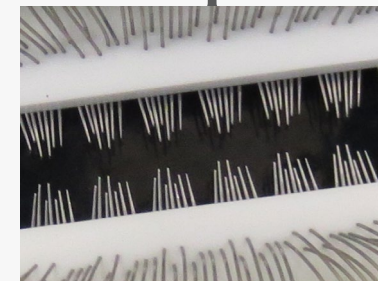
Parametric Test

Device Labs

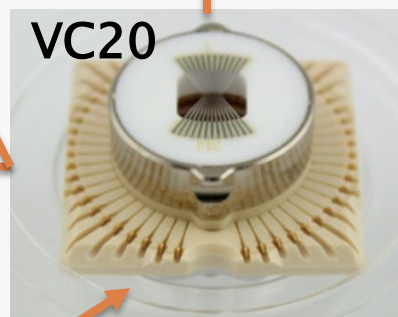
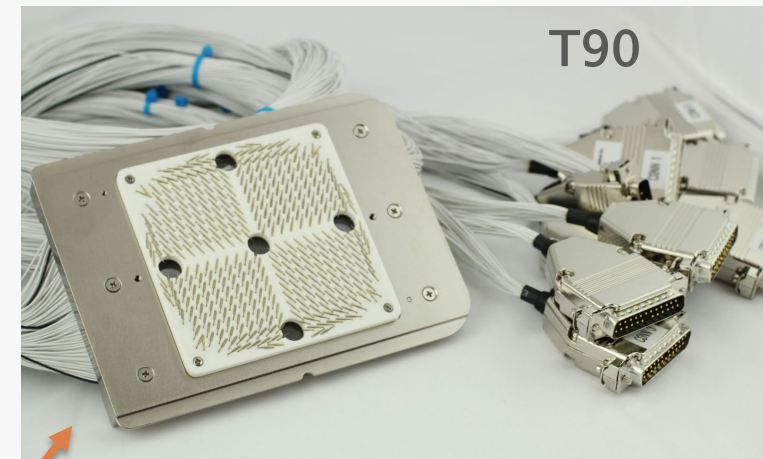
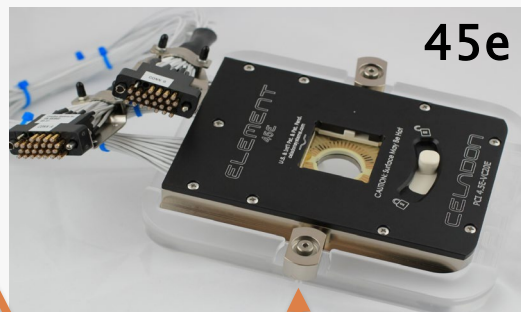
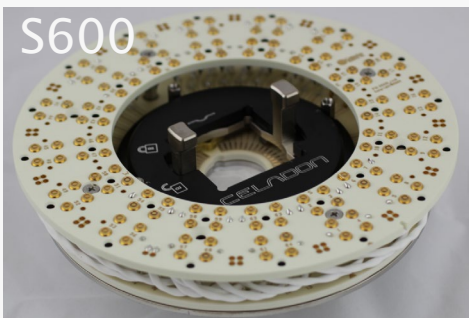
High Volume Manufacturing



Lower Pin count Multiprobe

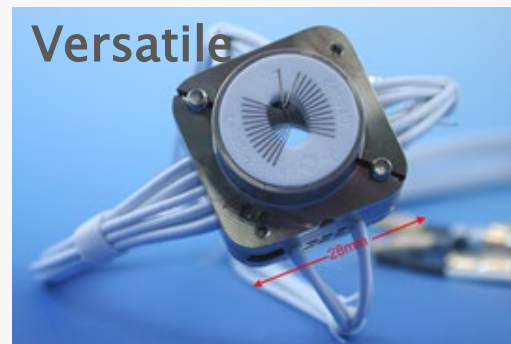
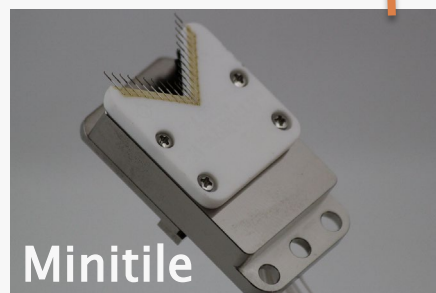


CELADON'S SINGLE-SITE AND MULTI-SITE PROBE CARD AND CABLE EXAMPLES



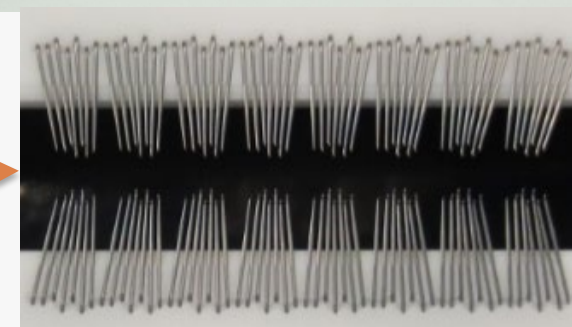
Single-site
probe cards

Positioner mounted



Multi-site
probe cards

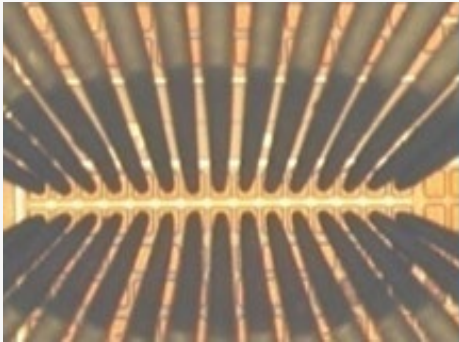
Cables



Triaxial Cable

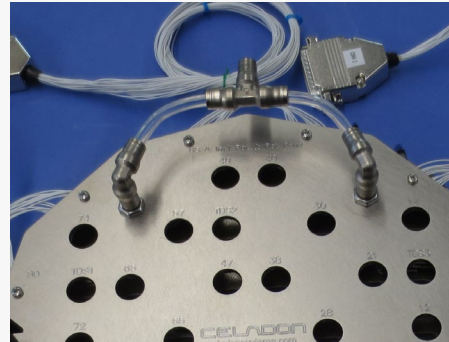


CELADON'S KEY DIFFERENTIATORS



Accurate Measurements

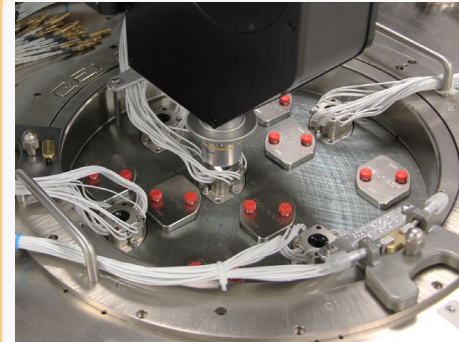
Low noise, low
leakage, high
accuracy
measurements
Ultra Low Leakage
Small sub-30 μ m pads



Extreme Temperature

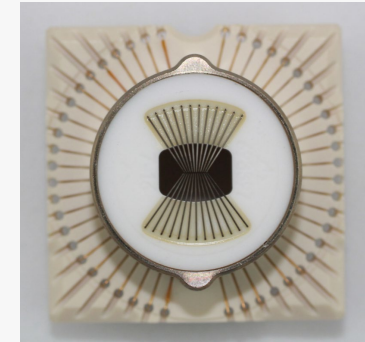
Wide operating
temperature

-65C to 600C
4, 7, 77 Kelvin



Versatile: Fixed and Adjustable Multi-Site

*Flexible,
innovative
solutions*

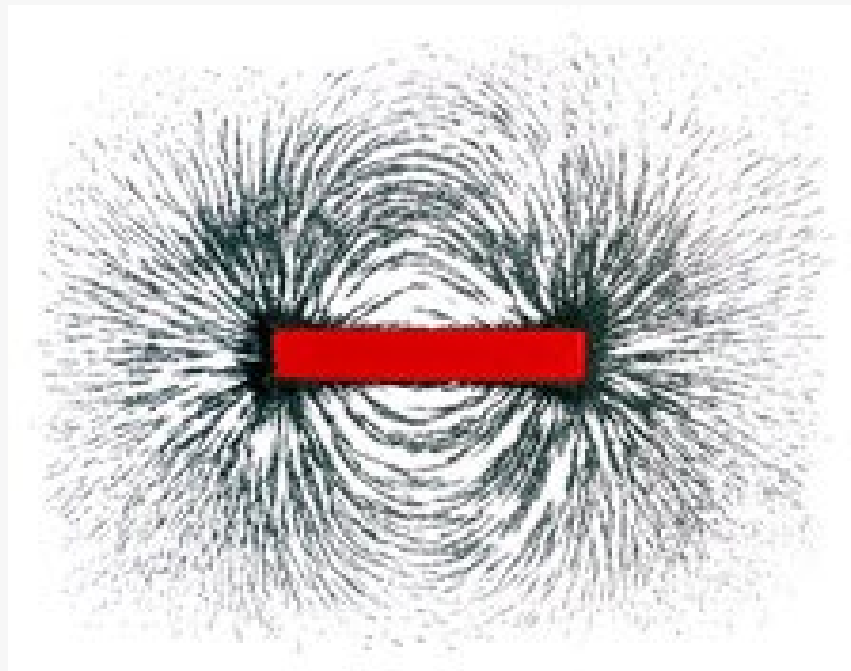


Robust and Long Life

Low maintenance,
low cost of
ownership
*Millions of
touchdowns*



Magnetic Applications



NON-FERROMAGNETIC PROBE CARD, EXAMPLE 1

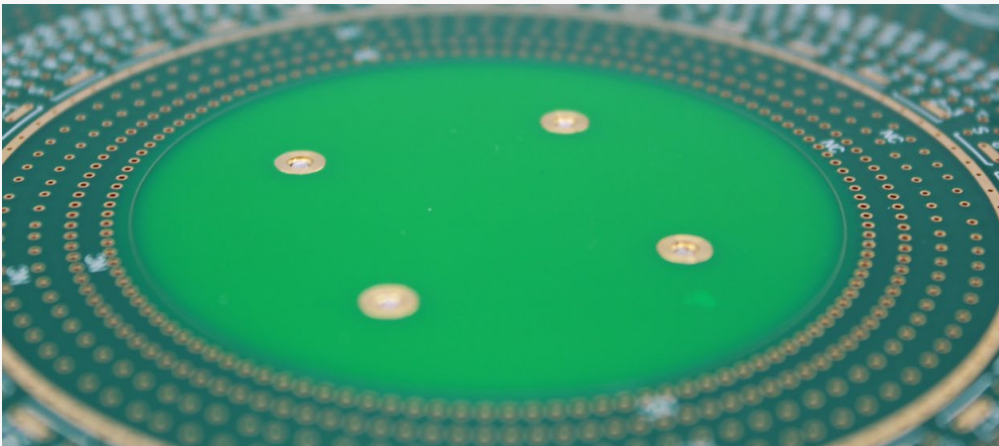


Customer unable to achieve thermal stability with existing MRAM probe card set up so they turned to Celadon

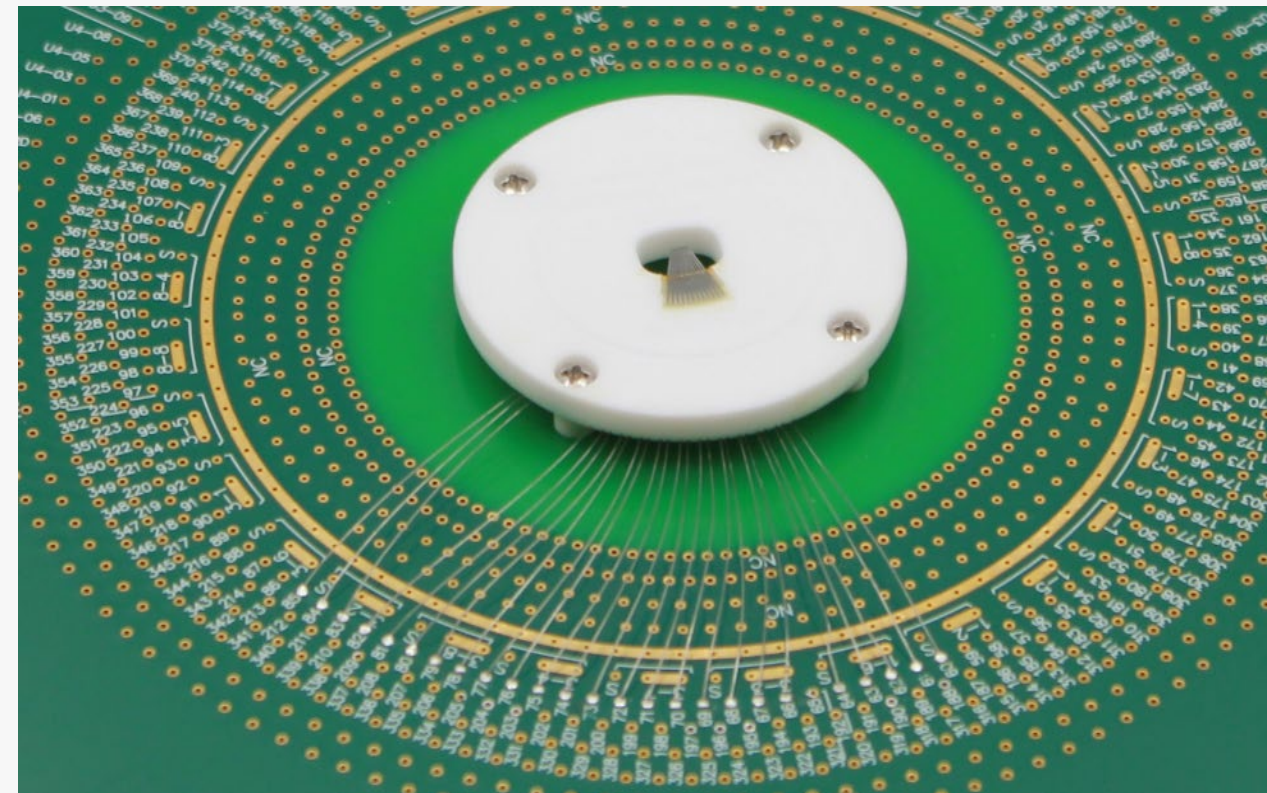
Successful implementation of a non-ferromagnetic probe card and Celadon overcame the following challenges:

- Accommodate existing GMW 5203 vertical magnet
- Total distance between top of probe card to tips ~13mm's which we achieved by adding a spacer
- Temperature range -40 to 150C
 - *Achieved thermal stability on 35 micron pads*

Wafer side



Magnet side



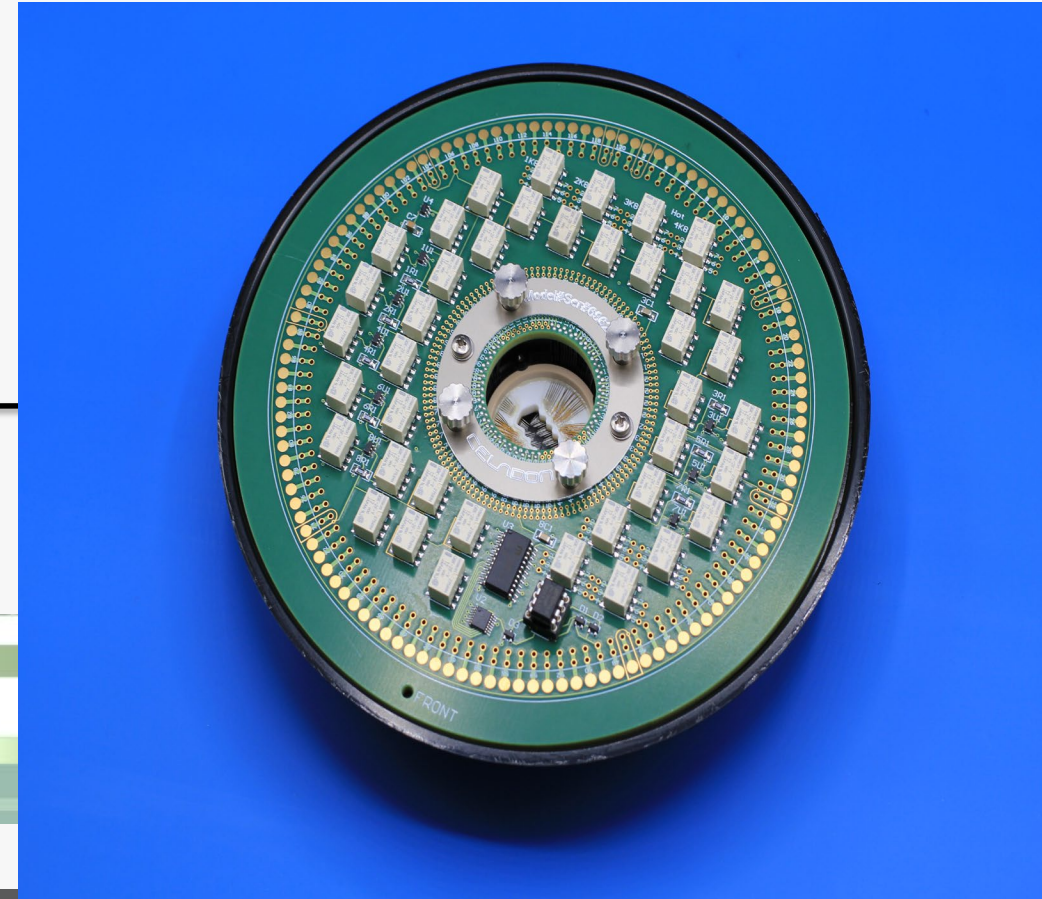
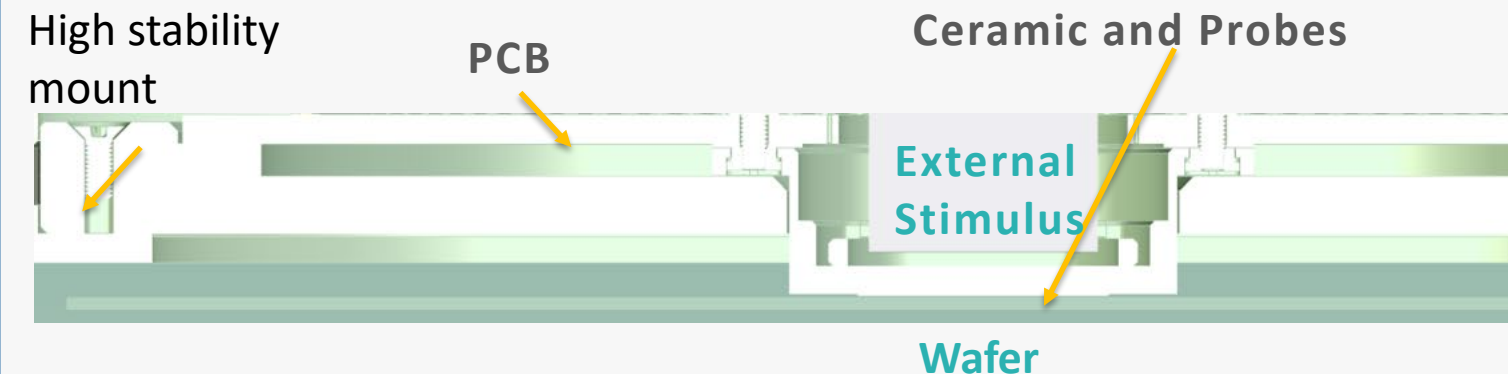
NON-FERROMAGNETIC PROBE CARD EXAMPLE 2

Customer was unable to achieve thermal stability with existing MRAM cards over temperature after working with several probe card suppliers, so they turned to Celadon.

Successful implementation of a non-ferromagnetic probe cards and Celadon overcame the following challenges:

- Thermal Stability:
 - On 60 micron pads
 - Temperature testing: 150C (card rated to 200C)
 - Very low profile stack up
 - Achieved by Celadon thinning ceramic to reduce thickness
- Lifetime performance is exceptional for this production application
- Millions of touch downs, few rebuilds over the years

Cross Section of Probe Card



CELADON – GMW VERTICAL FIELD SOLUTION INTEGRATION, EXAMPLE 3



Several years back, Celadon and GMW Associates were requested to develop an integrated solution using the GMW 5203 vertical magnet coupled with the Celadon VC20e™. The VC20™ is our most popular modular probe card because it offers many advantages over dedicated probe cards. First of all, it is quick change and can be shifted easily from one style board to another - *less than a minute change time using our Insertion Tool.*

VC20™ can handle up to 48 channels, ultra low leakage and is rated -65 to 200C

Keithley S530/S400

VC20e™

Keithley S600

Less cards needed

**Expect Millions
of touch downs!**

Less set up time

"Lab to Fab"

Custom
cabled-out

Keysight
4080
4072
4062

PCI-45e

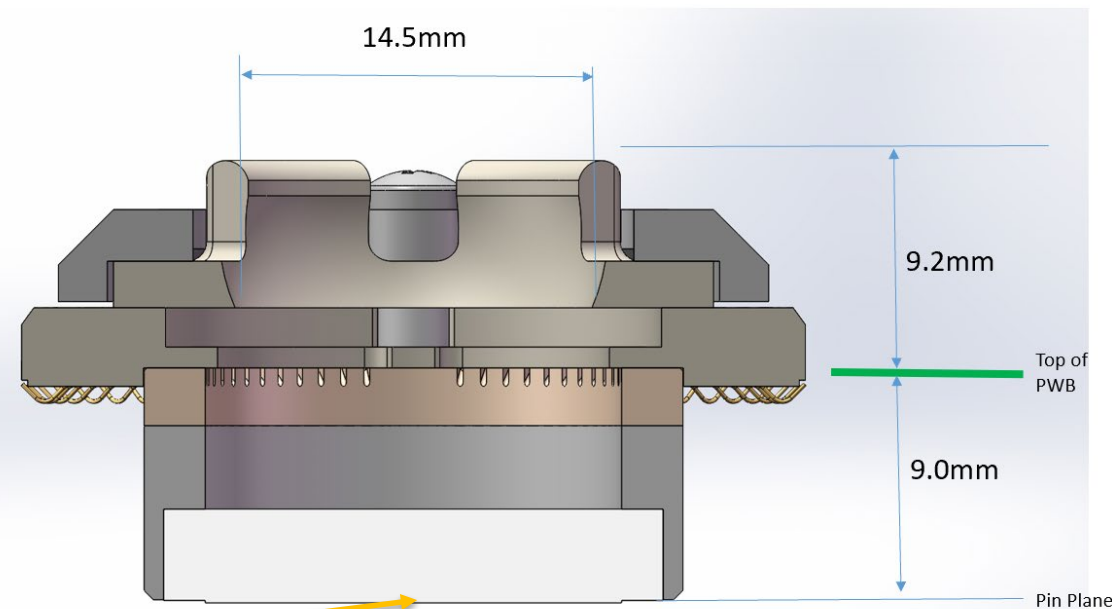
CELADON™

CHALLENGES USING THE VC20™ IN A MAGNETIC SET UP

- The set up the customer desired was the VC20™ *plus* Keysight 4080 motherboard. Using this setup “as is” prevented the GMW magnet from being close enough to the DUT to get the field density required.
- The challenge was to find a way to overcome the physical distance between the magnet and the DUT.

Cross section of the VC20™ Probe Card

You're in the way!



9.2mm + 8.83mm + .25mm
~18.28mm magnet to probe tips

Ceramic and Probes

DEVELOPMENT OF THE PATENTED MAGNETIC POLE EXTENDER

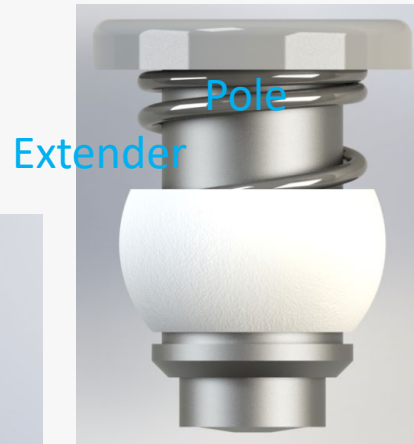
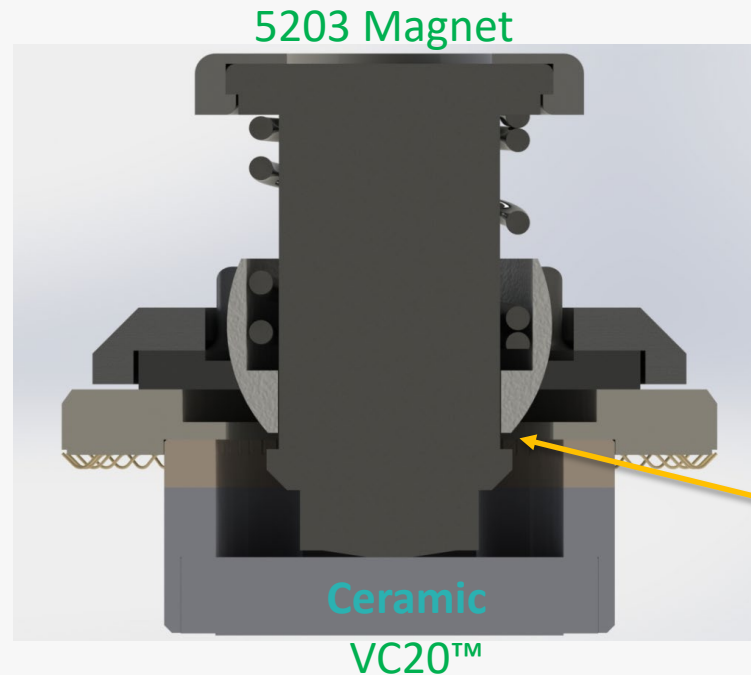


- To get the magnet close enough to the DUT to achieve customers required field, Celadon had to manufacture a solution that would extend the magnetic focal point of the 5203 vertical magnet lower and closer to the DUT.
- Celadon partnered with GMW Associates and developed a ***Magnetic Pole Extender with a spring mechanism*** and a process to create custom pole extenders going forward.
 - GMW used Celadon VC20™ models and a simulated customer die to model and calculate the optimal shape of the Magnetic Pole Extender which Celadon used to manufacture it.
- Here is what is unique about this patented Pole Extender:
 - It snaps into the back of the non-ferromagnetic VC20™ probe card.
 - We integrated a Spring Mechanism:
 - When the unit is turned on, it automatically shifts the pole extender to the 5203 magnet.
 - It absorbs dimensional variations of the test head and magnet within a specific range.
 - It prevents the pole extender from moving too quickly and slamming into the magnet face causing damage when the unit is turned on.

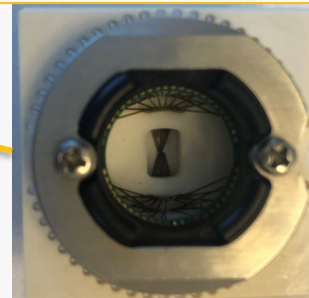
MAGNETIC POLE EXTENDER

The 5302 vertical magnet rests as close as possible to the top of the VC0e™ probe card with the Pole Extender in place.

Ball Socket Interface from Pole
Extender to VC20

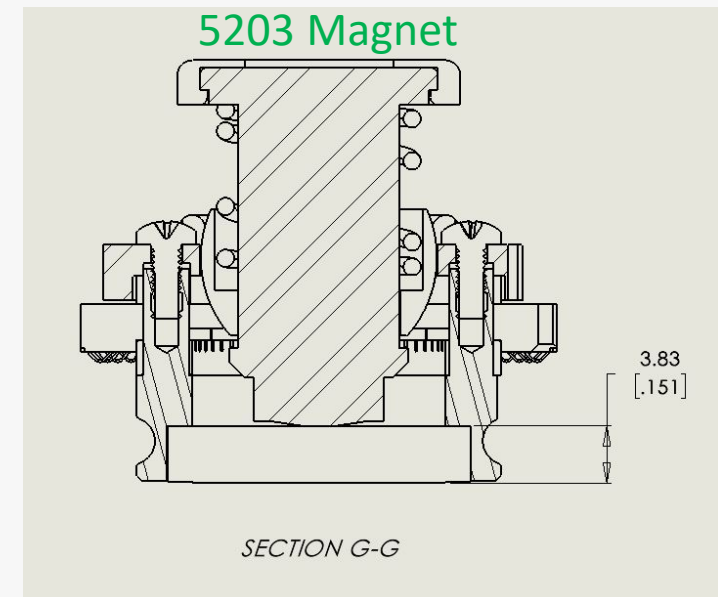


VC20™ Ball Socket



VC20 Ceramic

From the bottom of the pole extender to probe tips
~4.0mm



FINAL INTEGRATION MODEL OF GMW 5203 VERTICAL MAGNET AND CELADON VC20™



GMW 5203 Vertical Magnet

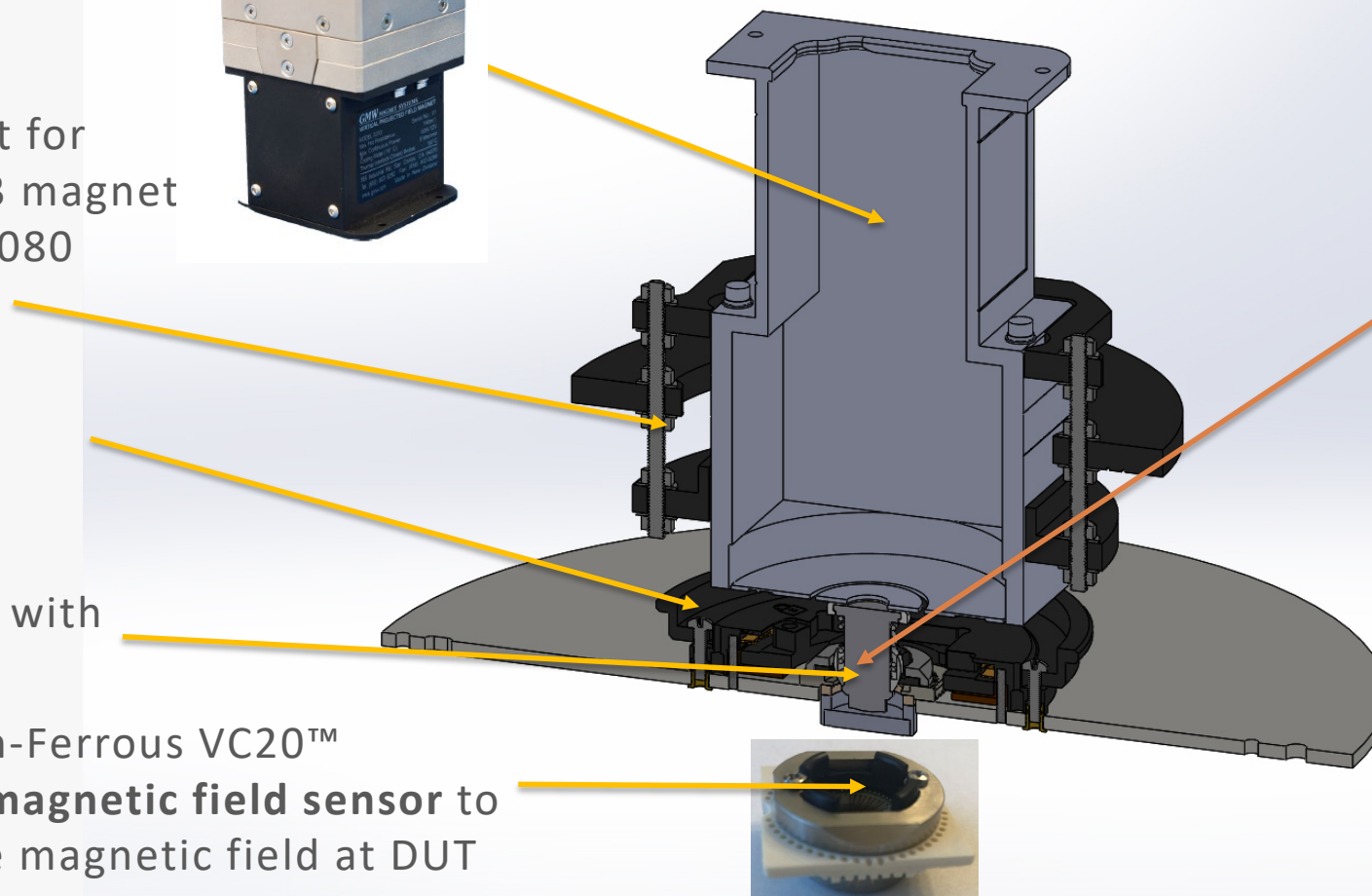


Celadon Docking Unit for mounting GMW 5203 magnet in Agilent/Keysight 4080 camera tunnel

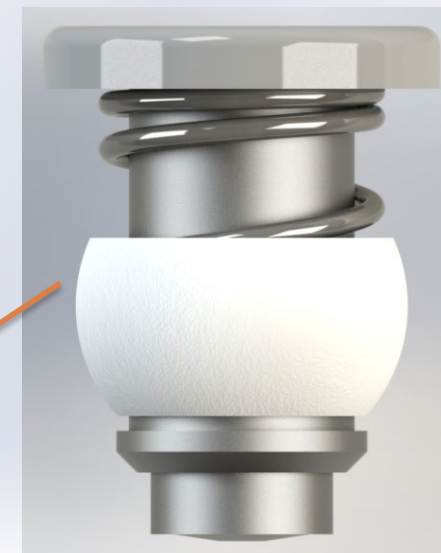
Celadon Non-Ferrous Latch assembly

Celadon pole extender with spring compression

Celadon Non-Ferrous VC20™ including a **magnetic field sensor** to calibrate the magnetic field at DUT



Pole Extender



CELADON – GMW HORIZONTAL MAGNETIC FIELD SOLUTION INTEGRATION, EXAMPLE 4

Celadon and GMW Associates were requested to develop an integrated solution using the GMW 5201 magnet to produce a Horizontal Magnetic Field over a specific DUT.

- To fit the type of pole extender required for this request, Celadon and GMW agreed that GMW would calculate, design, and manufacture the 2x poles needed to produce the horizontal field the customer required.
- Celadon would design non-ferromagnetic MiniTiles™, with a custom chassis to give the GMW poles mechanical clearance.
- MiniTiles™ would be held by positioners with RF adapter arms from 2 sides.
- Probe card alignment:
 - ⇒ Using an overhead microscope, perform the alignment, then when ready to probe and test, the microscope would be swapped with the GMW 5201 magnet.
 - => With an upward looking camera, the magnet would remain in place during the probe card alignment process.

MiniTile™ example



MODEL OF THE INTEGRATED 5201 MAGNET WITH CELADON MINITILES™



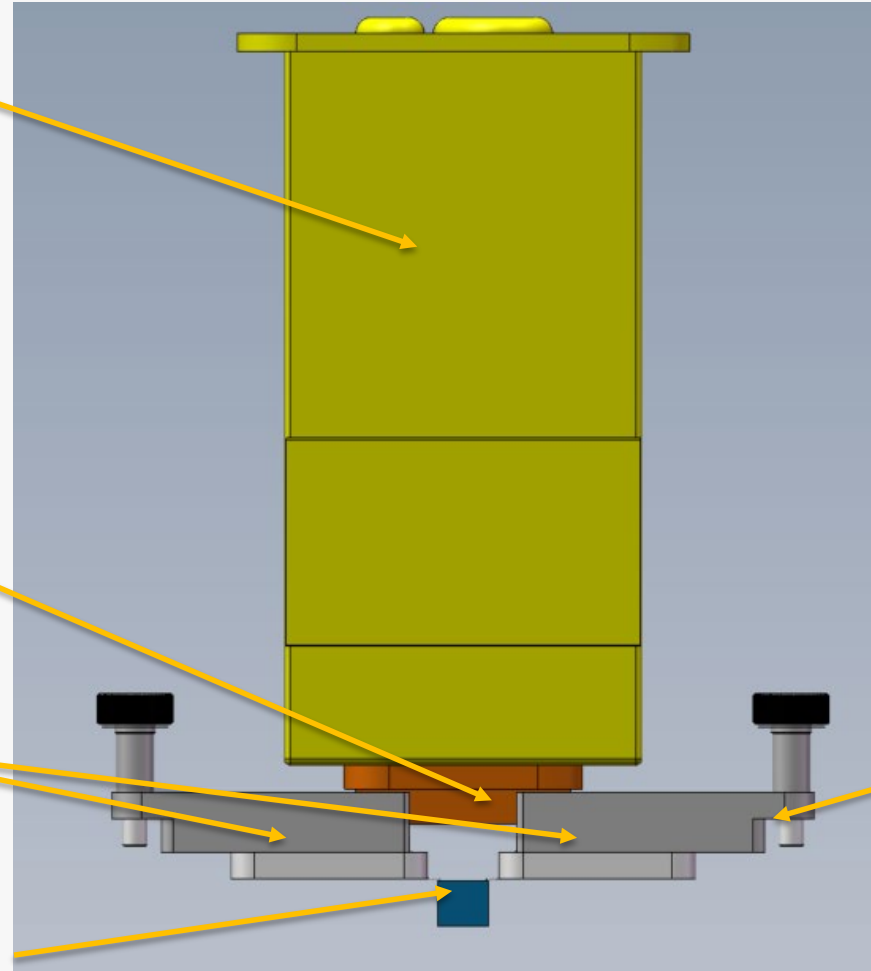
GMW Associates 5201 Magnet



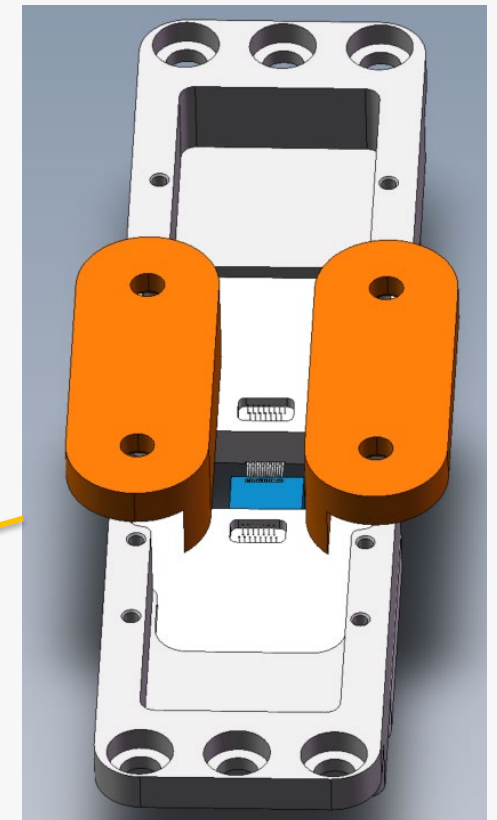
GMW Associates Pole Extenders

Celadon Non-Ferrous MiniTile™ x2 [wires not shown]

Customer DUT

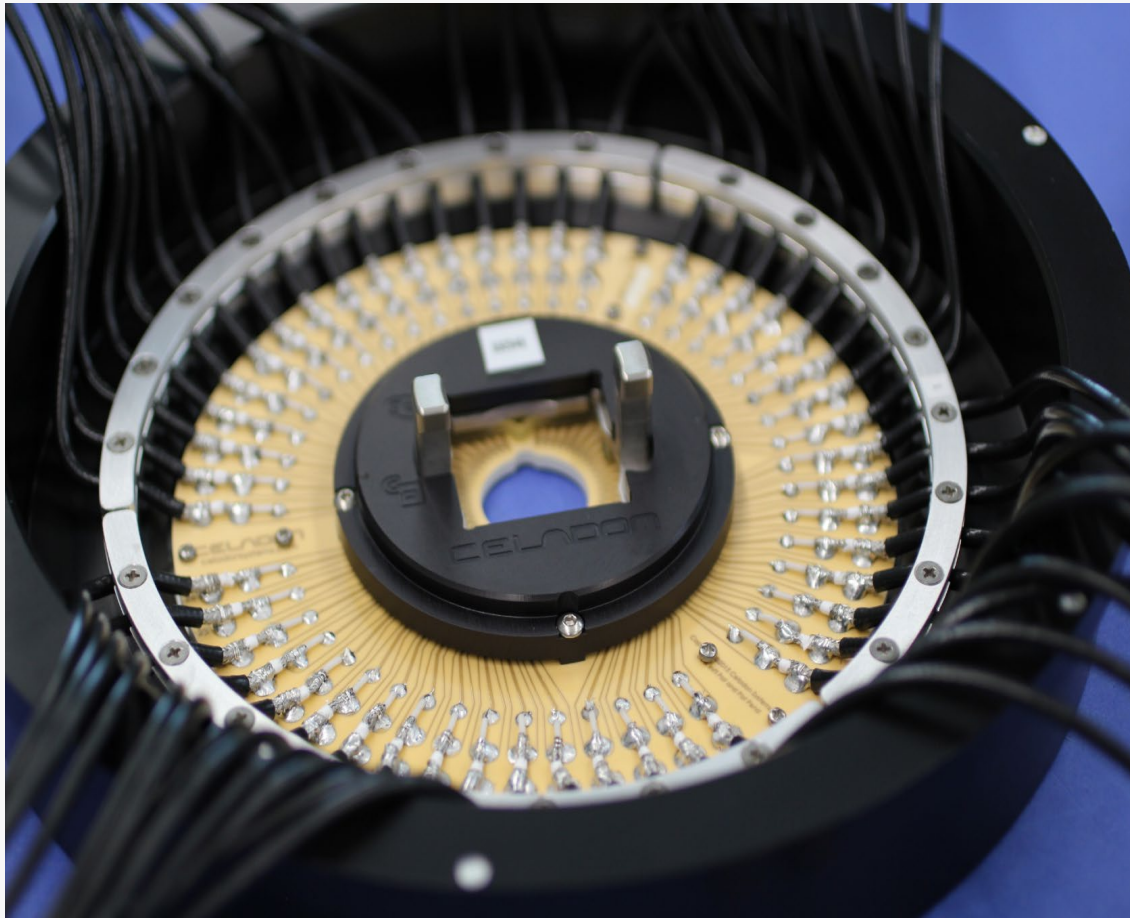


Celadon Non-Ferrous MiniTile™ x2 [wires not shown]



CABLED-OUT GMW 5203 OR 5207 MAGNETIC INTEGRATED VERTICAL SOLUTION, EXAMPLE 5

Celadon custom cabled-out motherboard



**Celadon
Pole Extender**



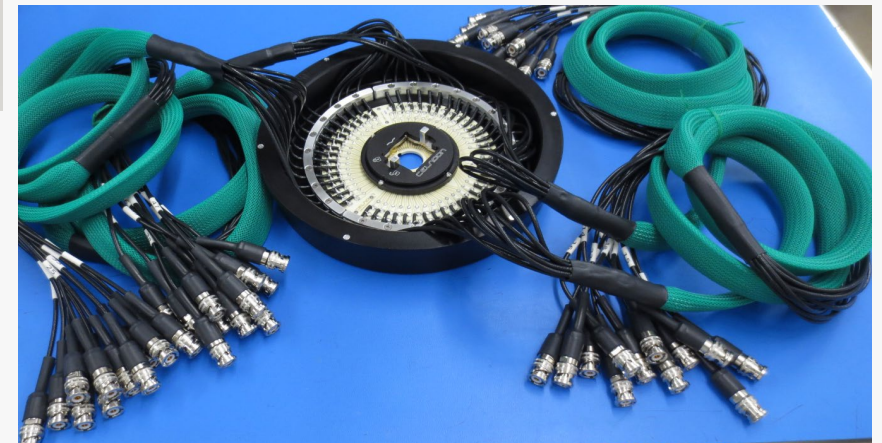
VC20™



GMW 5207 Magnet OR GMW 5203 Magnet



Celadon custom cabled-out motherboard



SUMMARY



I hope you can see that Celadon and GMW have worked hard over the years and have streamlined the integration process. At this point, we have a collection of modular parts that we can easily bring together to create custom integrated solutions and we can do so very quickly.

Please reach out to us with your on-wafer magnetic testing challenges!



THANK YOU



Thank you to the GMW Associates and Celadon Integration Team for all of their hard work to develop these innovative and well-needed solutions.

Bill Funk, Celadon Systems

Tom King, GMW Associates

Garrett Tranquillo, Celadon Systems

Brian Richter, GMW Associates

Spintronic On-Wafer Testing

An integrated Solution

GMW*Associates*

Presented by:

Tom King
GMW Associates
tom@gmw.com

1

GMW Associates

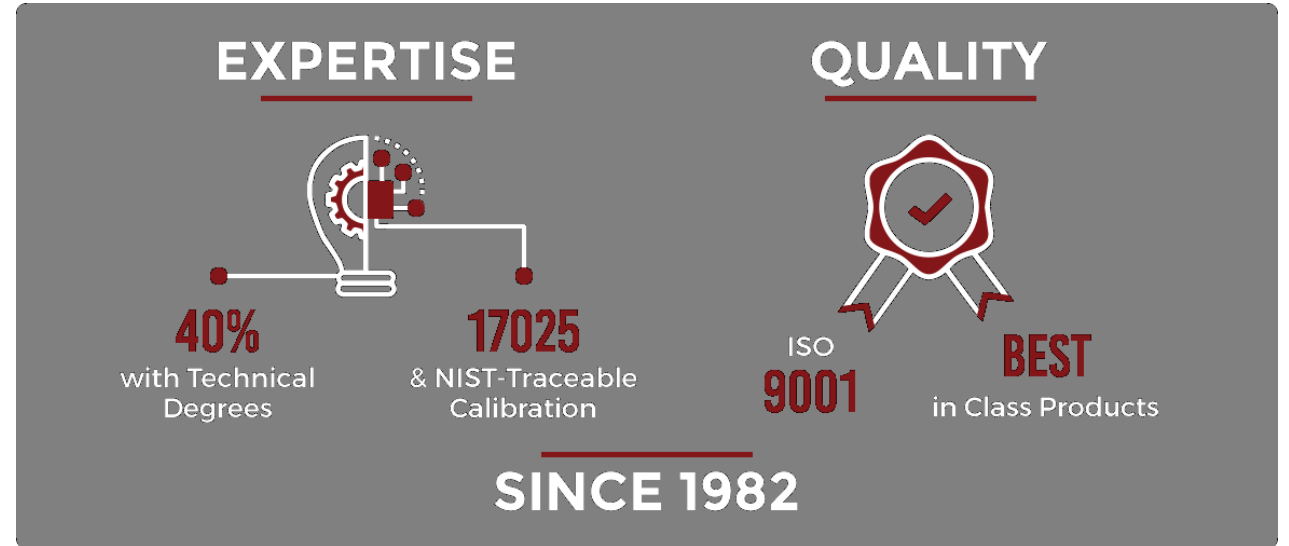
Products and Expertise

GMW*Associates*

GMW Associates - Overview

GMW is the designer, integrator, and distributor of Magnetic Systems and Instrumentation based on Magnetics.

- Founded in 1982
- Staff of 20, over 40% with technical degrees
- Headquarters in San Carlos, California (30 miles from San Francisco)



Products and Services

Electromagnet Systems

- Dipole Magnets
- Projected Field Magnets
- High Uniformity Magnets
- Magnetic Modeling & Design

Instrumentation

- Magnetic Field Measurement
- Electric Current Measurement

Calibration and Service

- 17025 Accredited Calibration Lab
- Magnetic Field Mapping
- Magnetic Site Survey

GMW Associates – Electromagnet Systems

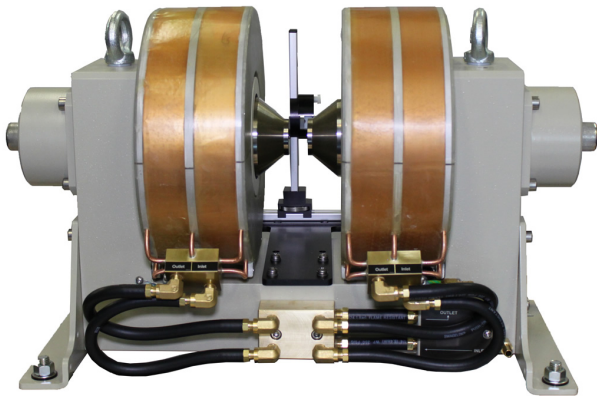
Complete Electromagnet Systems, Including:

- Electromagnet
- Chiller
- Power Supplies
- Control Software
- Magnetic Modelling and Custom Designs

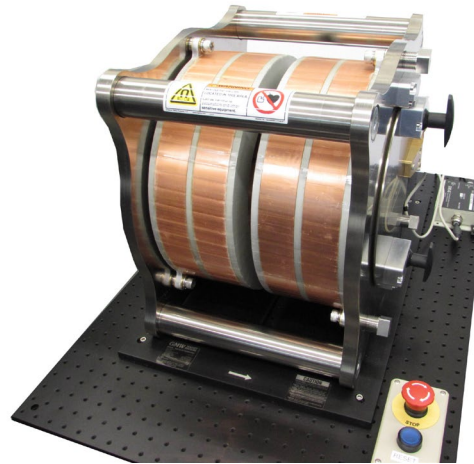
Typical Applications:

- EPR
- Spintronics
- NV Centers
- Mössbauer
- FMR
- MOKE
- Neutron Beam Line
- Materials Research
- Low Resolution NMR
- Ion Implantation
- VSM

Dipole Electromagnets



High Uniformity Electromagnets



Projected Field Electromagnets



2

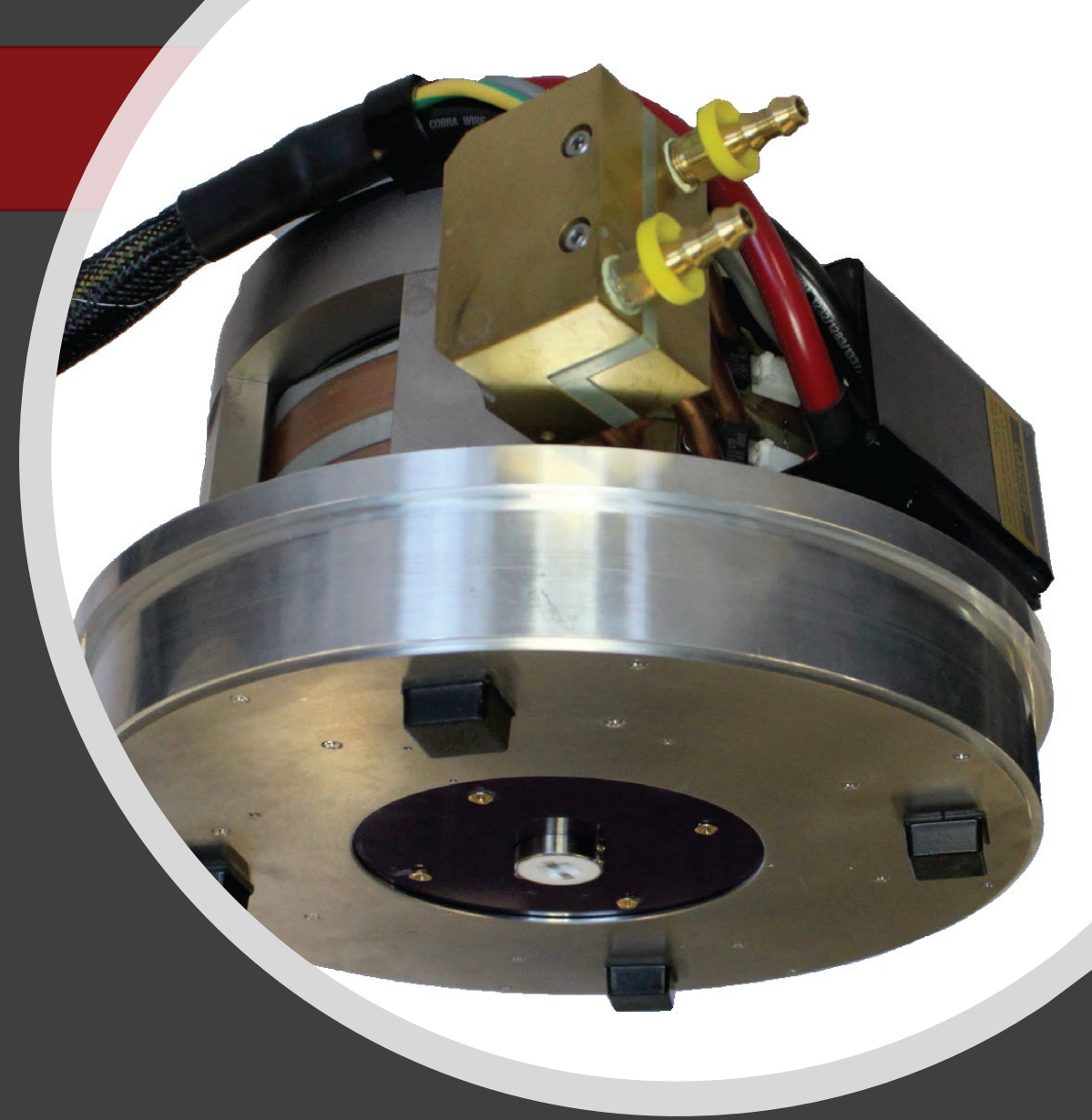
Integration with Celadon

How integration takes the work out of
in-field testing

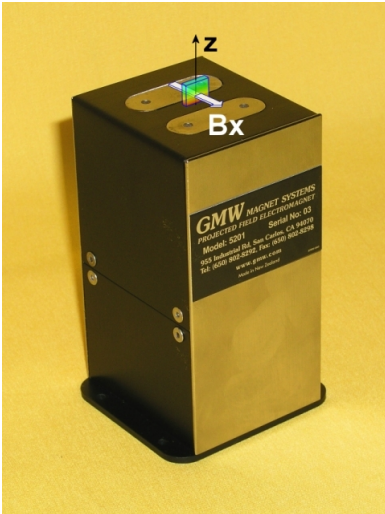
GMW*Associates*

GMW and Celadon Prober Integration

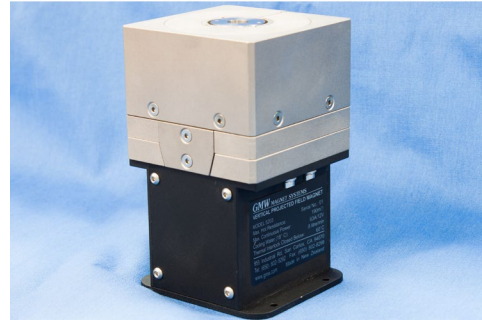
- Spintronic On-Wafer testing facilitated by projected field magnets
- Integrating magnet and probe card requires both products to be compatible
- Customized magnetic field and contact configuration make compatibility difficult
- GMW and Celadon work together to make the solution to customer specification



GMW and Celadon Prober Integration

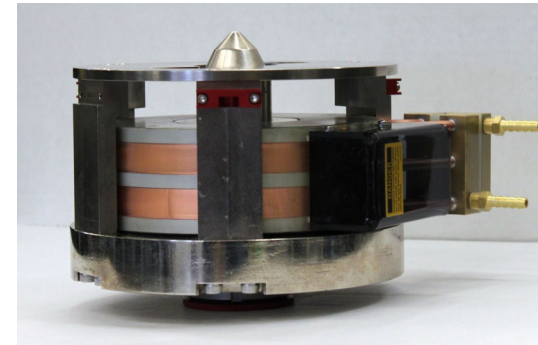


5201
In-plane field
2.5 kg
74x74mm footprint



5203
Out-of-plane field
2.5 kg
74x74mm footprint

	5201 35A triangle 20A DC	5203 100A triangle 63A DC	5207 60A triangle 35A DC
Maximum Instantaneous Field for a Single Device	Optimized to order	~2T	~2T
Maximum Instantaneous Field for a 4mm Array	0.50T No extensions	0.52T	>1T
Maximum Continuous Field for a Single Device	Optimized to order	1.68T	1.9T
Maximum Continuous Field for a 4mm Array	0.40T No extensions	0.38T	0.77T



5207
Out-of-plane field
20 kg
Ø200mm footprint

GMW and Celadon Prober Integration



Spintronic On-Wafer Testing - An integrated Solution

GMWAssociates

3

Magnetic Configurations

Field Profiles and Field Shaping

Getting the right solution

GMW*Associates*

Configurable Magnetic Solutions



Pole A - standard



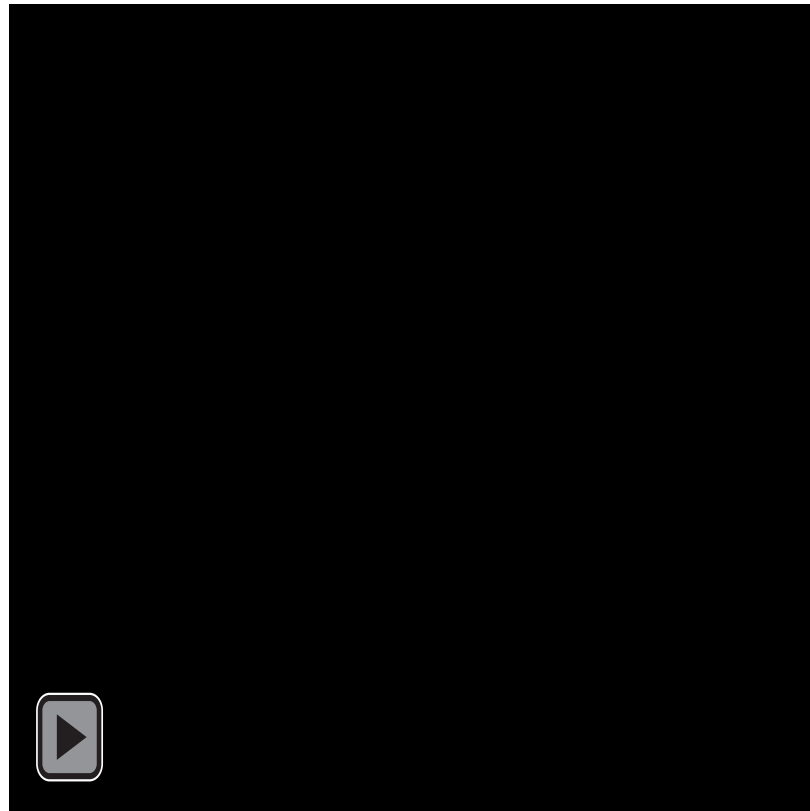
Pole B



Pole C



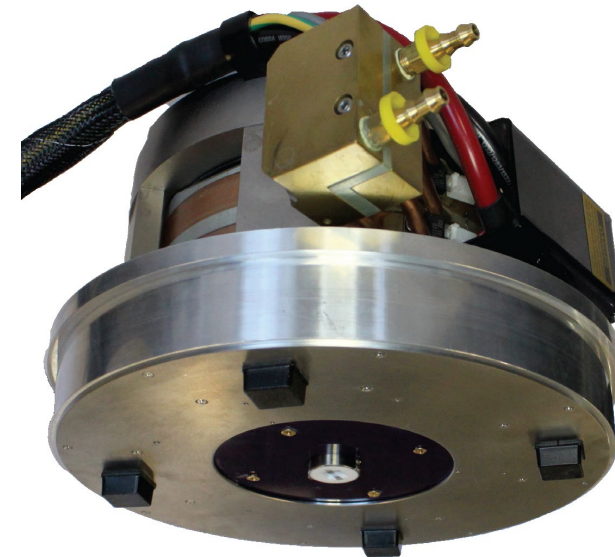
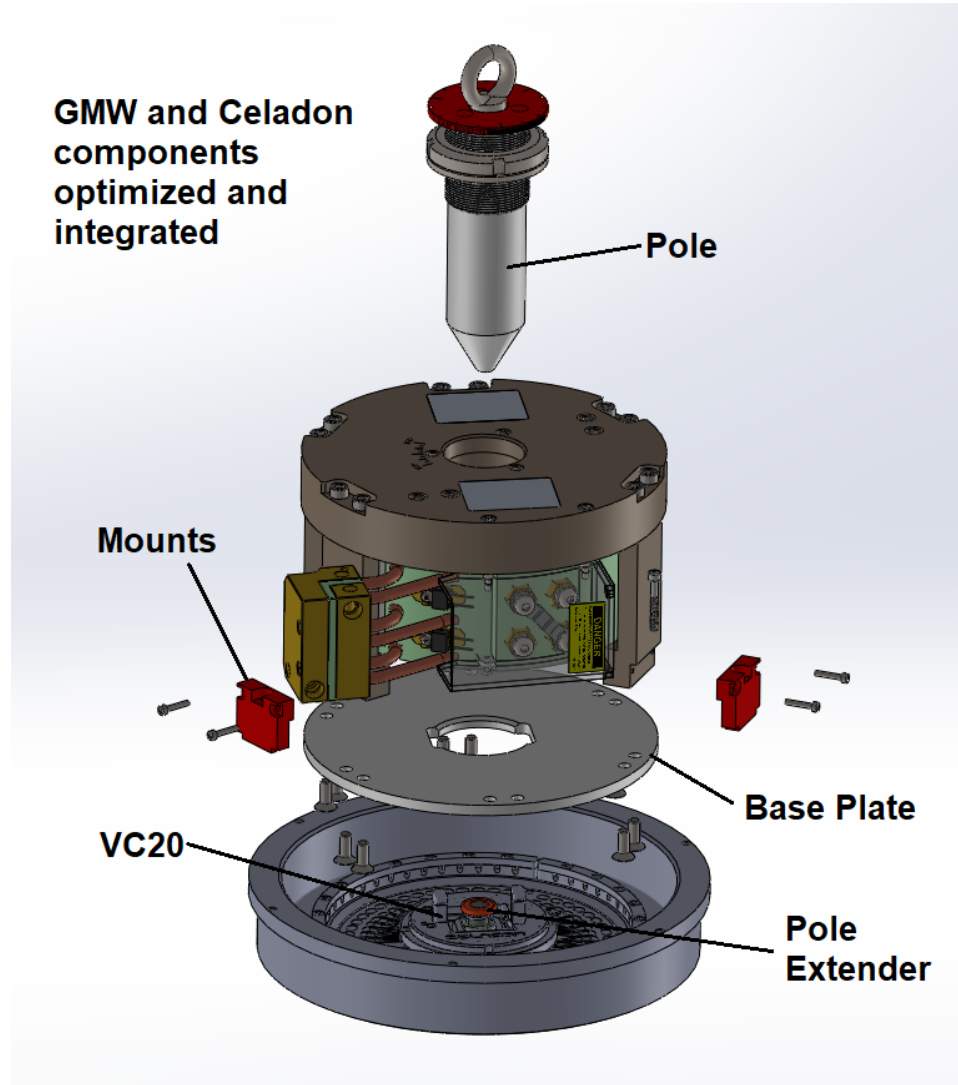
Pole D



AIT Milliscope™ Borescope



Configurable Magnetic Solutions



4

Two Industry Solutions

MRAM Test

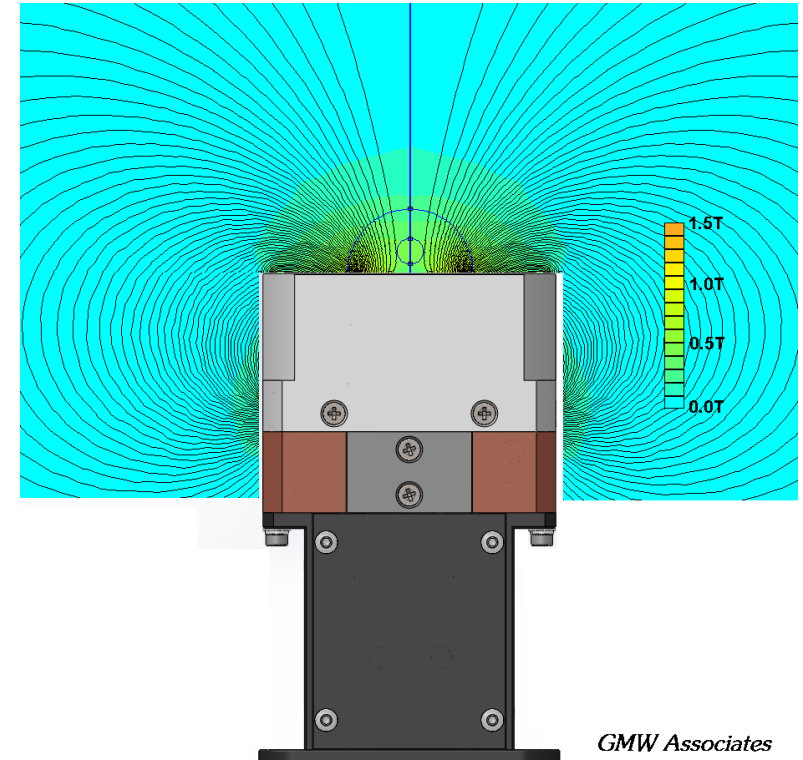
GMW*Associates*

Parametric and Functional Array Testing

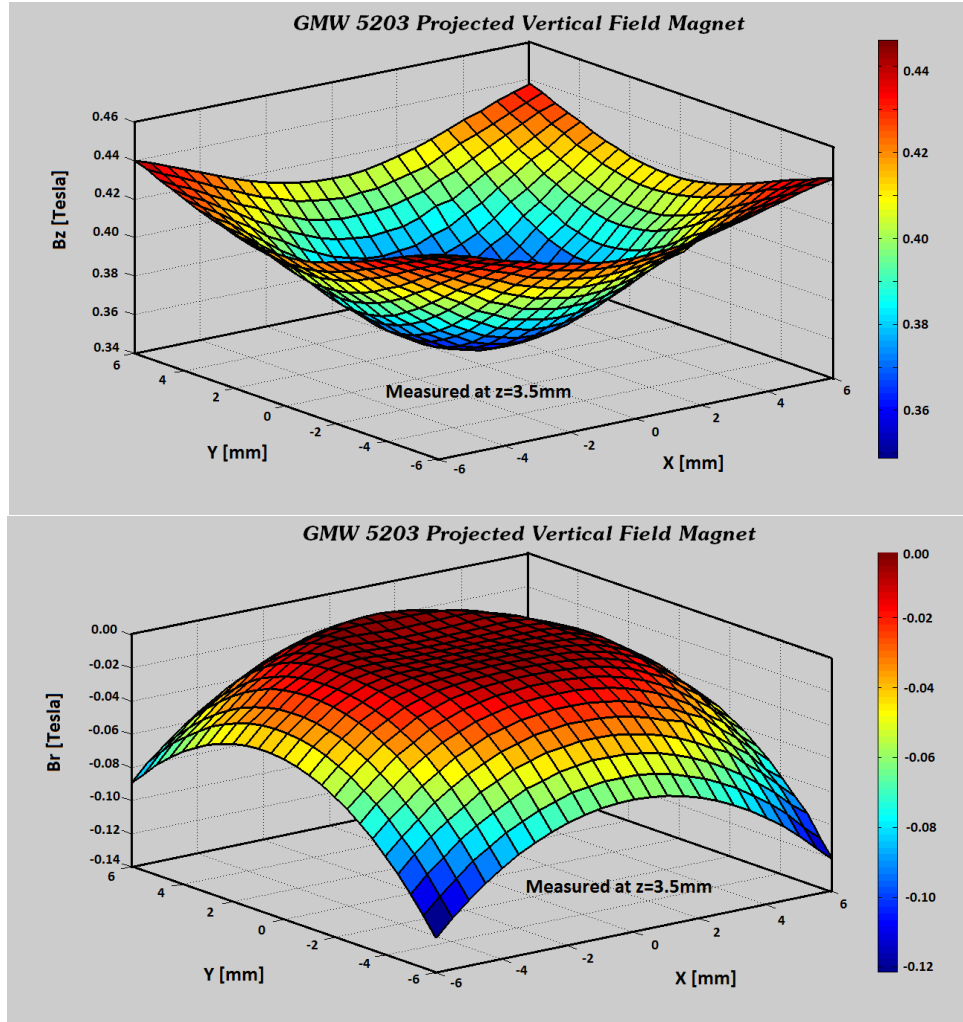
5203 used for MRAM test over 4mm square array.

Requirements:

- >0.5T Out-of-Plane field – Field sweep Triangle Waveform
- ~0.35T Out-of-Plane field – Static continuous field
- Array 3.5mm from magnet pole to allow for contacts
- <1% In-Plane Field
- ~1% Field variation over 4mm square MRAM array
- Weight <3kg to allow for magnet and microscope interchange



Parametric and Functional Array Testing



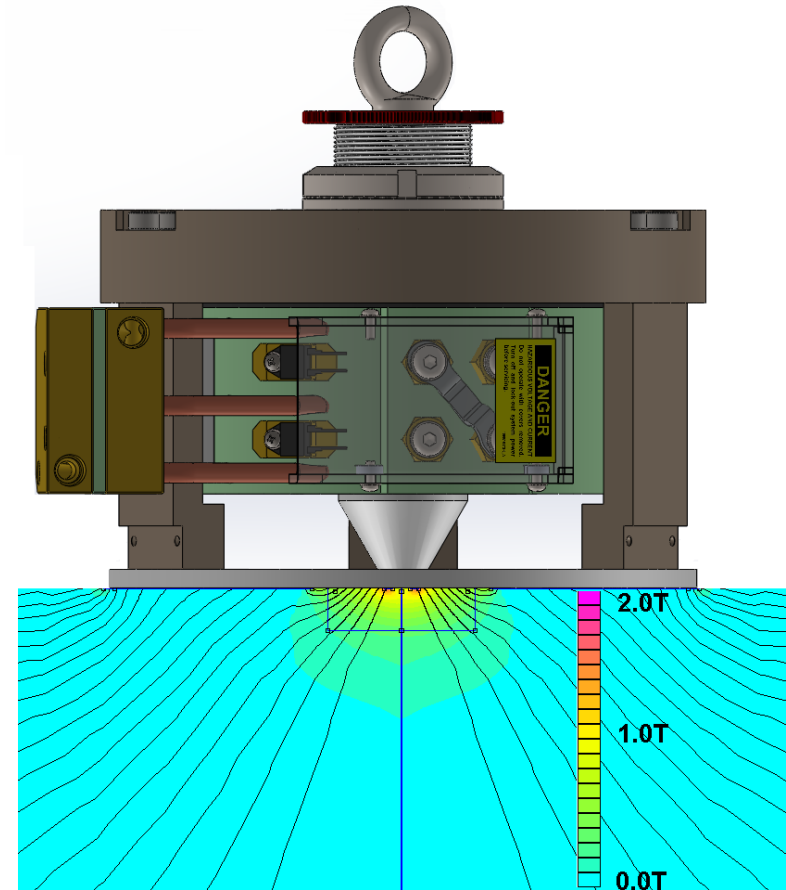
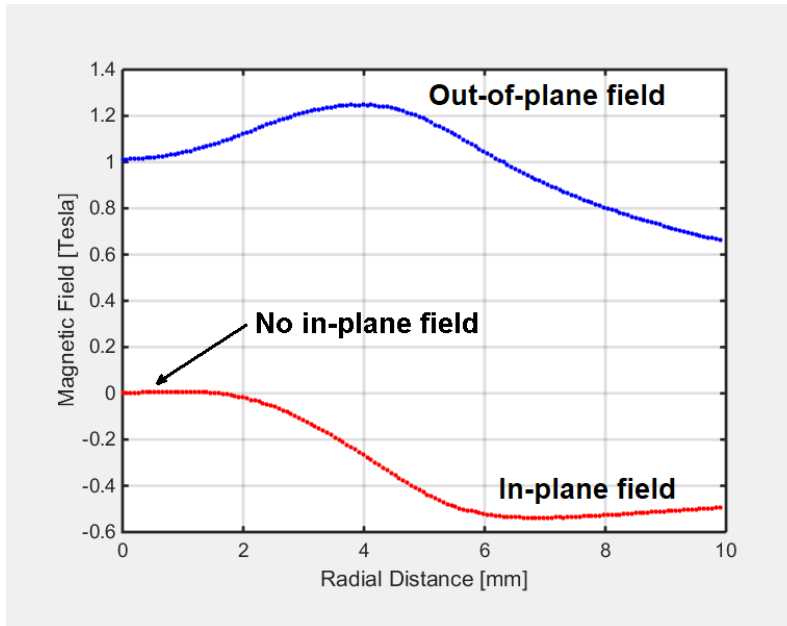
Solution provides a static field of 0.38 Tesla or a swept field of amplitude 0.52 Tesla. The amplitude variation over the array is a few percent.

The more strict criterion is for the array to experience the minimum possible in-plane field during test. The in-plane field is kept to within 10 Gauss over the whole array.

Spintronic Device Test

5207 used for Spintronic test over 2x3mm array.

- >1T peak field (Triangle Waveform)
- Very low tolerance for in-plane field < 2mT
- Sample 1mm from pole (no contacts)
- Magnet is permanently in place, weight <20kg



Thank You!



Tom King



Email: tom@gmw.com



www.gmw.com



1-650-282-2339

GMW*Associates*



Questions?

Please enter any questions into the chat box, thank you!



Tom King, PhD

tom@gmw.com

Lead Magnet Scientist
GMW Associates



Karen Armendariz

karen.armendariz@celadonsystems.com

CEO
Celadon Systems



Bill Funk

bill.funk@celadonsystems.com

Chief Technical Officer
Celadon Systems