The Newsletter from Quantum Design

Spring 1997, Issue No. 6

Quantum STATES

QUANTUM DESIGN:

GREETING FROM THE PRESIDENT

It is a very special privilege to introduce myself to the readers of *Quantum States* for the first time. To bring some of you up-to-date, after 14 years with Quantum Design, co-founder and former president W. Barry Lindgren announced his resignation to the Board of Directors last summer, and they reluctantly accepted his decision to leave in the pursuit of other business opportunities. In my former role as Director of Sales, Marketing and Customer Service, I was already well acquainted with the products, customers and international sales representatives of Quantum Design. When the Board of Directors offered me the position of President, I saw it as a unique chance to expand our influence in the marketplace through development of new products and to build on the extraordinary growth Quantum has enjoyed during the last year.

Due in part to the introduction of our MPMS-XL line, the steady popularity of the original MPMS systems and the increased demand for our PPMS products, Quantum Design experienced record sales in 1995 and 1996. We increased the number of our international sales representatives including a new representative in Brazil. In addition we created a centralized European Service Center in Darmstadt, Germany. Now our most important tasks are to continue the expansion of our core business internationally, while developing business plans to keep the company on a steady growth path. Our plans for future products and markets are exciting; the creative energy in the halls and labs at QD is contagious.

For those of you new to *Quantum States*, welcome! I think you will find this issue uniquely informative for those involved in the superconductivity industry. I would like to hear your comments by e-mail or on the internet. For readers who have come to anticipate the publication of another issue of *Quantum States* for its technical articles and industry-wise commentary, enjoy! This is an exciting time to be part of Quantum Design and the opportunity to determine the path to the future that we will follow makes the challenge of my new position doubly exciting.

Please feel free to contact me personally to introduce yourself or with questions, suggestions or comments about our products, service or markets. I look forward to hearing from you!

Best regards,

Jerry Daviess
President

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CROSSTALK

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SERVICE

A high sensitivity tool: the miniaturized piezoresistive torque magnetometer

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In materials science there is an increasing demand for investigating ever smaller magnetic or superconducting objects down to submicrometer scale. For this purpose, high sensitivity magnetometers are required. Superconducting QUantum Interference Devices (SQUIDs) are very useful instruments to measure magnetization properties of materials but are usually rather slow in performing measurements as a function of magnetic field and are not optimally suited for angular dependent measurements. A very interesting alternative is the torque magnetometer which has a fast response time and has proven to be a very powerful tool in investigating the intrinsic magnetic and superconducting anisotropy properties of single crystals and thin films.

Several types of sensitive torquemeters have been proposed. The earliest version is the suspension torquemeter based on the torsion of a support wire. It has been brought to a high level of sophistication by Farrell et al. [1] but due to its size it remains sensitive to external perturbations and thus is more difficult to use. A more advanced version is the capacitance torquemeter in which a flexible beam holding the sample is symmetrically positioned between two capacitor plates [2]. The deflection Δz of the beam produced by the magnetic torque $\vec{\tau} = \vec{m} \times \vec{B}$, where $\vec{m}$ is the magnetic moment of the anisotropic sample plunged in an homogeneous magnetic field $\vec{B}$, can be measured by means of a capacitance bridge. Torque sensitivity in the range $\Delta\tau \cong 10^{-12}$ nm could be achieved with such a device using soft and thin metallic beams.

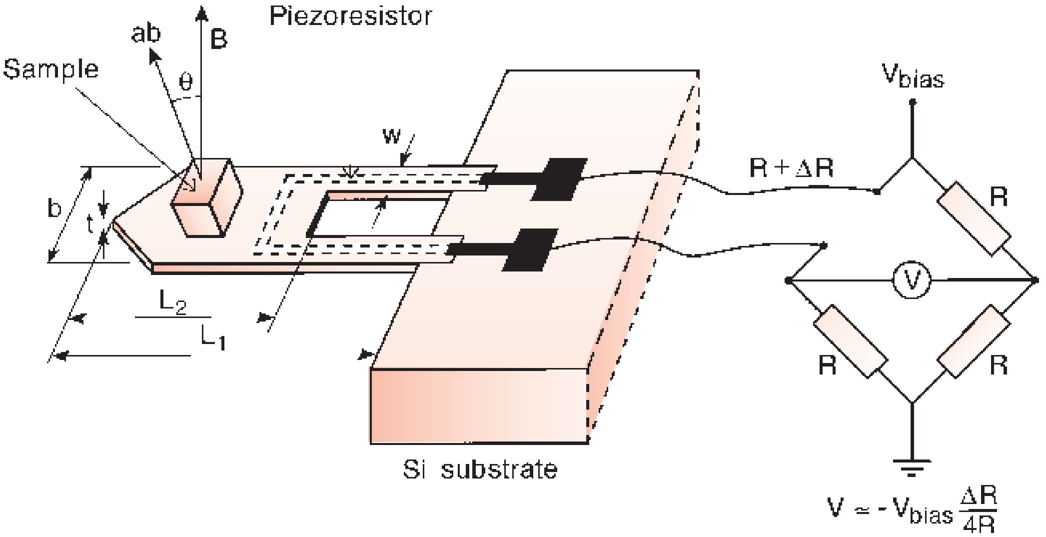

Figure 1: *Schematic of piezoresistive torquemeter with Wheatstone bridge.*

Inspired by the technology of atomic force microscopy (AFM) we have developed, in a combined effort between IBM Rüschlikon and the University of Zürich, an ultrasensitive miniaturized torquemeter [3] based on microfabricated silicon piezoresistive cantilevers. On the surface of the cantilevers a piezoresitive path is made out of a thin layer of p-doped silicon with a typical room temperature resistance of 2 kΩ. The deflection of the free end of the lever produced by the torque τ on the sample, is proportional to the change in piezoresistance ΔR which can be simply measured by a Wheatstone bridge (Fig.1). The piezoresistive cantilevers were first proposed for AFM studies by Tortonese et al. [4] and have been commercialized by Park Scientific Instruments [5]. Piezoresistivity is a good alternative to the usual optical readout proposed in many AFM instruments and has the advantage of simplicity and easy usage under UHV and low temperature conditions. For our torquemeter we have used cantilevers of typical thickness $t = 4\ \mu\text{m}$, length $L_1 \cong 165\ \mu\text{m}$ and width $b \cong 90\ \mu\text{m}$. The sensitivity given by the percentage change in piezoresistance per nm of deflection Δz, can be measured or calculated. Based on the the lever geometry and its elastic properties it is found to be

$$\frac{\Delta R}{R} = \frac{2}{3}\beta\pi_L\bar{\sigma}_{\max} = \beta\pi_L Et\,\frac{L_1+L_2}{2(L_1^3-L_2^3)}\Delta z \cong 10^{-7}\text{–}10^{-6} \tag{1}$$

where π_L is the longitudinal piezoresistive coefficient of <110> Si, $\bar{\sigma}_{\max}$ the average maximal stress at the surface of each arm of the lever, E the Young's modulus, β a correction factor close to 1 and L_1, L_2, t, w the dimensions of the lever. As described in ref. [3], the lowest measurable torque is given by the smallest deflection (typically 0.01–0.1 nm) which can be accurately measured over a given time scale and upon minimization of the different noise sources. Replacing in equation (1) $\bar{\sigma}_{\max}$ by its given expression $\bar{\sigma}_{\max} = 3\tau / wt^2$, the torque sensitivity can be estimated to be

$$\Delta\tau = \frac{wt^2}{2\beta\pi_L}\frac{\Delta R}{R} \cong 2\cdot 10^{-14}\text{–}10^{-13}\,\text{N}^{-13}/\text{m}$$

at room temperature. With appropriate temperature stability, a proper choice of bandwidth and using a second bare cantilever as reference in a differential setup, magnetic moments as small as $m \geq 10^{-14}\ \text{Am}^2$ at 1 Tesla can be measured. This is typically up to 3 orders of magnitude better than usual SQUID magnetometers. The magnetic moment m of a sample of magnetization M and volume V is given by $m = VM$ where V is the volume of the sample.

Our microtorquemeter is particularly well suited to take fast field dependent torque data $\tau(H)$, investigate time relaxation phenomena $\tau(t)$ or make angular dependent experiments $\tau(\theta)$ by rotation in a magnetic field. Here θ is the angle between the applied field and a specific crystallographic axis of the investigated crystal. The small size of the piezoresistive torquemeter is moreover of advantage for reducing the influence of external linear acceleration (gravity) and makes it also easy to implement it in any existing cryomagnet.

An important point is the adequate calibration of the torquemeter. One way is to add a calibration loop directly on the platform of the cantilever in order to produce a well defined moment. Unfortunately the need to connect this loop with a metallic path on the arms has the drawback of changing their elastic and thermal properties (bilayer effect) and the overall sensitivity. In the case of superconducting samples the calibration can be directly done by taking advantage of the linear slope $M = -H/(1-N)$ in the Meissner state for $H < H_{c1}$, assuming that the shape of the sample is simple enough to make a proper estimate of the demagnetization factor N. As an example, Fig. 2 shows the torque and corresponding magnetization data of a microcrystal of the high-Tc superconductor $Bi_2Sr_2CaCu_2O_8$ (Bi – 2212, $T_C = 84$ K) with a mass of 720 ng and typical dimensions

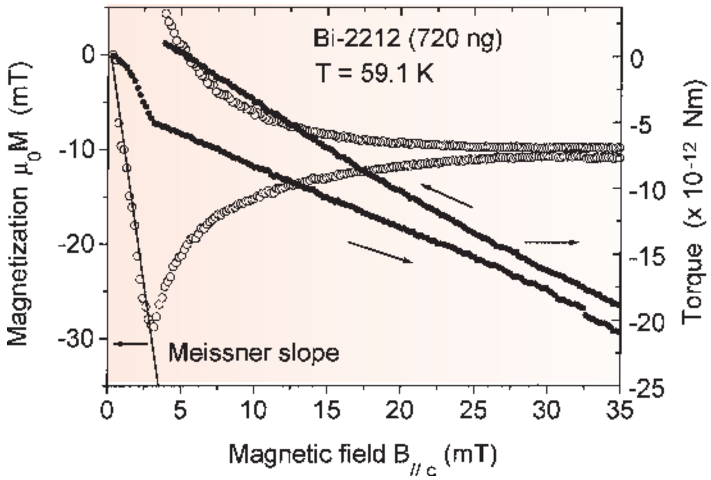

Figure 2: *Torque and corresponding magnetization of Bi-2212 single crystal versus c-axis component of applied magnetic field. The straight line below 3 mT (Meissner state) is used to calibrate the amplitude of the torque signal [3].*

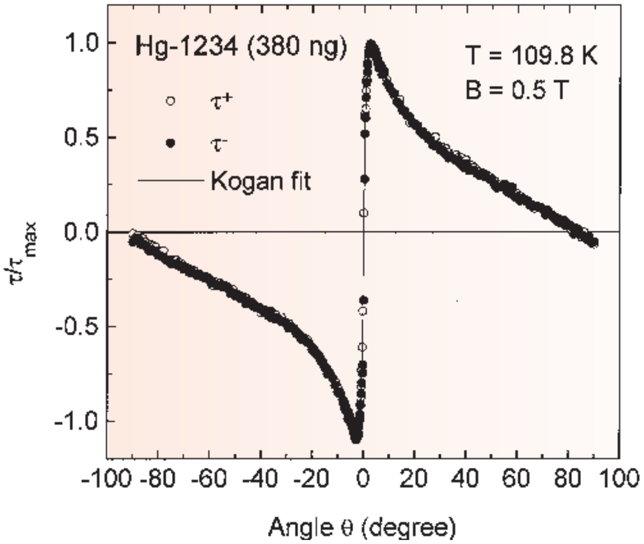

Figure 3: *Torque rotation measurement of a microcrystal of Hg-1234 at T = 109.8 K and B = 0.5 T. The normalized torque signal is almost fully reversible over the whole angle range, and can be fitted with the Kogan formula for a 3D anisotropic superconductor [6].*

100 x 120 x 10 μm^3. In this case the angle between the applied field and the ab plane (i.e., CuO_2 layers) of the crystal was $\theta = 60^\circ$. Using a demagnetization of N = 0.9 for the crystal platelet, the conversion factor between the signal in volts and the magnetization $\mu_0 M$ in Tesla can be derived from the Meissner slope and used to calibrate the torque signal.

Another very useful application of the torquemeter is high-precision angular-dependent torque measurements $\tau(\theta)$. This has been demonstrated very successfully again for high-temperature superconductors where pinning and important intrinsic microscopic parameters can be derived. In general the torque signal is monitored by rotating the sample in the field clockwise (τ^+) and counterclockwise (τ^-). The irreversible torque $\tau_{irr} = (\tau^+ - \tau^-)/2$ yields information on the dissipation due to flux lines movements, i.e. on the critical current density, whereas the reversible torque $\tau_{rev} = (\tau^+ + \tau^-)/2$ can be analyzed by means of different theoretical models. An example of the reversible torque measured on a single crystal of the mercury-based cuprate, $HgBa_2Ca_3Cu_4O_{10}$ (Hg – 1234, T_C = 113 K) is shown in Fig. 3. By fitting the curve with the proper equation (Kogan formula) based on the 3-dimensional anisotropic London model, the following three fitting parameters can be derived: the upper critical field B_{c2}^{C} (T = 0) = 63.3 T along the c-axis, the in-plane London penetration depth $\lambda_{ab}(0)$ = 130 nm as well as the effective mass anisotropy $\gamma = \sqrt{m_c^* / m_{ab}^*} = 52$ [6]. From the upper critical field the in-plane coherence length can be determined as ξ_{ab} = 1.8 nm. More details are given in ref. [6].

In summary we have shown that piezoresistive cantilevers can be easily and advantageously used to make a miniaturized, highly sensitive torque magnetometer for the investigation of anisotropic magnetic or superconducting microcrystals. Its implementation in the Physical Property Measurement System (PPMS) of QD will open the door to many new experiments on micro- or submicrometer objects.

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NSF'S MRSEC PROGRAM:

An Experiment in New Ways of Conducting Materials Research

Two years ago, the National Science Foundation established a new program of Materials Research Science and Engineering Centers (MRSEC) at universities. NSF awarded grants to eleven centers at ten universities in the first round of MRSEC competition. In October of 1996, NSF announced the results of the second competition and funded thirteen more centers. These centers are receiving $500,000 to $5 million from NSF annually for up to five years, with a competitive review in year four. In total, the twenty-four centers are receiving about $43 million of NSF funding annually. This article illustrates the scope of the program, which has already become a pillar of American materials science research.

Program Concept
Lance Haworth, NSF Program Director, explains the justification for the MRSEC program: "Last year, NSF published its Strategic Plan, which cites three major goals. First, to uphold our position of world leadership in all aspects of science, math, and engineering. Second, to promote discovery, integration, and employment of new knowledge in service to society. Third, to achieve excellence in scientific, mathematical, and technological education at all levels. The MRSEC program fits squarely within that framework. Its goals are to support interdisciplinary research and education in materials and to address fundamental, complex problems that are important to society."

Interdisciplinary Research
Each MRSEC is composed of one or more Interdisciplinary Research Groups (IRG's). Malcolm Beasley, Director of Stanford's Center for Materials Research, emphasized that the structure of the MRSEC program helps to overcome barriers between cooperation between departments. "Universities are so disciplinary structured, with deans and departments, that you need some institutional mechanism to work across boundaries. MRSEC provides the resources to make that happen."

Brage Golding, Director of the Center for Fundamental Materials Research at Michigan State University, stressed the practical importance of interdisciplinary research. "At Bell Labs or IBM, the key to success is getting people to work together – never mind your background; if you need to get something done, you do it," Golding said. "At the university, people are labeled physicists, chemists, and engineers, and people with different labels don't talk to each other. We're trying to link physicists and chemists who are doing fundamental studies with engineers who make devices and who, in turn, are close to industry people who need these innovations. A lot of synergy occurs when people apply different expertise to the same problem. The key to these centers is to provide an environment where people can come together, share their understanding, and learn to speak each other's language."

The IRG's are studying a broad range of topics and, in some cases, establishing new fields of research. At Princeton, for example, one group is studying biologically inspired processing of composites. Peter Eisenberger, Director of the Princeton Materials Institute, explained, "Nature solved the problem of ceramic brittleness in clam shells by making a composite in which ceramic layers alternate with thin organic layers. At Princeton, eight researchers from seven disciplines are working on various aspects of this problem, from synthesizing laminated materials to explaining why they work.

Some of our people are considering the use of organic biological systems to make new materials."

Another group at the Materials Research Laboratory at the University of Massachusetts at Amherst is also exploring the links between materials science and biological science. David Tirrell explained, "Certain bacteria accumulate 80% of their weight as biodegradable polyesters with mechanical properties similar to those of polypropylene. With chemical synthesis techniques, you always get mixtures of different chain lengths; however, with biological synthesis techniques, you can get nearly complete structural uniformity. Our researchers are designing structural proteins that regulate synthesis in the bacterial cells."

An IRG at MIT's Center for Materials Science and Engineering is making organic light-emitting diodes from strange molecular systems with semiconductor or metal particles surrounded by polymers. The researchers have found several new systems in which they can make highly efficient organic LED's with only 20 monolayers of polymer. "One potential application is flexible displays which you could unroll and hang on the airplane seat in front of you," said Marc Kastner.

Self-assembling polymers are the main research theme for a group at the Materials Research Laboratory of the James Franck Institute at the University of Chicago. "Since some parts of the polymers want to get away from other parts, they tend to form elegant and possibly useful structures on surfaces," explained Leo Kadanoff. "Our motivation is to develop a new integrated circuit technology in which we grow devices naturally from the atomic level up to nanoscale." Curtis Frank, Professor of Chemical Engineering at Stanford and Director of the Center on Polymer Interfaces and Macromolecular Assemblies, a partnership among research groups from Stanford, the University of California at Davis, and IBM Almaden Research Center, emphasized that the MRSEC program is helping researchers learn to conduct cooperative research in a way that breaks down barriers between institutions as well as departments. "We have to discover how to create a smoothly functioning team from a private university, a public university, and a corporate research lab – three institutions with different structures, different objectives, and different ways of doing things," Frank said. "Our contributions about how to do research in this mode may be as important as our specific science accomplishments."

Relationships with Industry

The MRSEC program encourages cooperation between universities and corporations. Princeton's Peter Eisenberger said, "By focusing support on materials problems with technological relevance, MRSEC helps us achieve a critical mass which makes those connections meaningful and attractive to industry as well."

Marc Kastner of MIT pointed out that the downsizing of industrial research helps to stimulate industrial interest in the MRSEC program. "All our research is very long range. Since the time scale for research in corporate labs is getting shorter, forward-looking industrial people are often interested in what we do."

In some cases, MRSEC groups are trying to improve processing techniques for established technologies. Purdue University's MRSEC for Technology-Enabling Heterostructure Materials is cooperating with Hewlett-Packard to improve the process for making bright red LED's for automobile tail lights and turn indicators. "The standard process is to grow AlInGaP LED's on lattice-matched gallium arsenide, then lift them off the GaAs and rebond them to gallium phosphide, a transparent substrate," explained Purdue's Jerry Woodall. "If we could learn to grow these LED's directly on a GaP substrate, companies could produce them a lot more cheaply."

In other cases, the motivation for the industrial relationship is to develop new technology. For example, researchers at Harvard's Materials Research Laboratory are cooperating with General Electric and United Technologies to develop thermal barrier coatings for jet engines. "The Harvard IRG includes people from various departments who are interested in stress in thin films, the mechanical properties of ceramics, and the fundamentals of fracture," said Frans Spaepen.

MRSEC Education

The interdisciplinary nature of the MRSEC program tends to broaden the academic experience of graduate students. "Many of our students are working in more than one lab and reporting in a formal way to two or more faculty advisors," said David Tirrell of the University of Massachusetts. "That's difficult to manage if you don't have the MRSEC mode of support."

The MRSEC program also exposes graduate students to industrial R&D. At Michigan State, for example, some of the graduate students and postdocs are conducting joint projects with automobile companies. Curtis Frank of Stanford even suggested that universities might integrate industrial internships into the standard curriculum. “Our students are seeing firsthand how people at IBM organize to solve a problem,” Frank said. “I think the MRSEC program is producing scientists and engineers with skills that are relevant to the country’s needs.”

Undergraduate Education

MRSEC programs support undergraduate education by sponsoring undergraduate research, supporting students who need supplementary work, and enriching the undergraduate curriculum in other ways. For example, the MRSEC at MIT sponsors a program in which undergraduates receive credit and sometimes payment for doing research. A MRSEC program at Michigan State supports the research component of a curriculum-based enhancement program for undergraduate minority students. “The program has a demonstrably high success rate, measured by the percentage of these students who receive their bachelor’s degrees,” Brage Golding commented.

Pre-University Education

MRSEC institutions sponsor educational outreach programs, working with K-12 students and teachers to increase their understanding of materials science and show them how materials science is connected to people’s lives. Some MRSEC programs send ambassadors to high schools, others bring high school students and teachers to the university. “At Stanford, we bring in high school students who have the interest and aptitude and put them through a benign bootcamp of real laboratory research,” said Malcolm Beasley. “If they’re really interested, we try to find them positions in a university lab or an industrial lab.”

Shared Experimental Facilities

NSF requires MRSECs to incorporate shared experimental facilities for researchers. Marc Kastner of MIT explained, “Every materials researcher requires a broad range of tools for processing and analysis. These instruments are often extraordinarily expensive. For example, we have one of the world’s best scanning transmission electron microscopes for doing chemical analysis on an atomic length scale. There’s no way we could afford an instrument like this at MIT without shared central facilities under MRSEC sponsorship. We make the central facilities available not only to the IRG’s, but also to individual investigators at MIT and even to researchers from other universities, hospitals, and corporations. The only limitation is that the capabilities we offer can’t be available commercially.”

Seed Funding

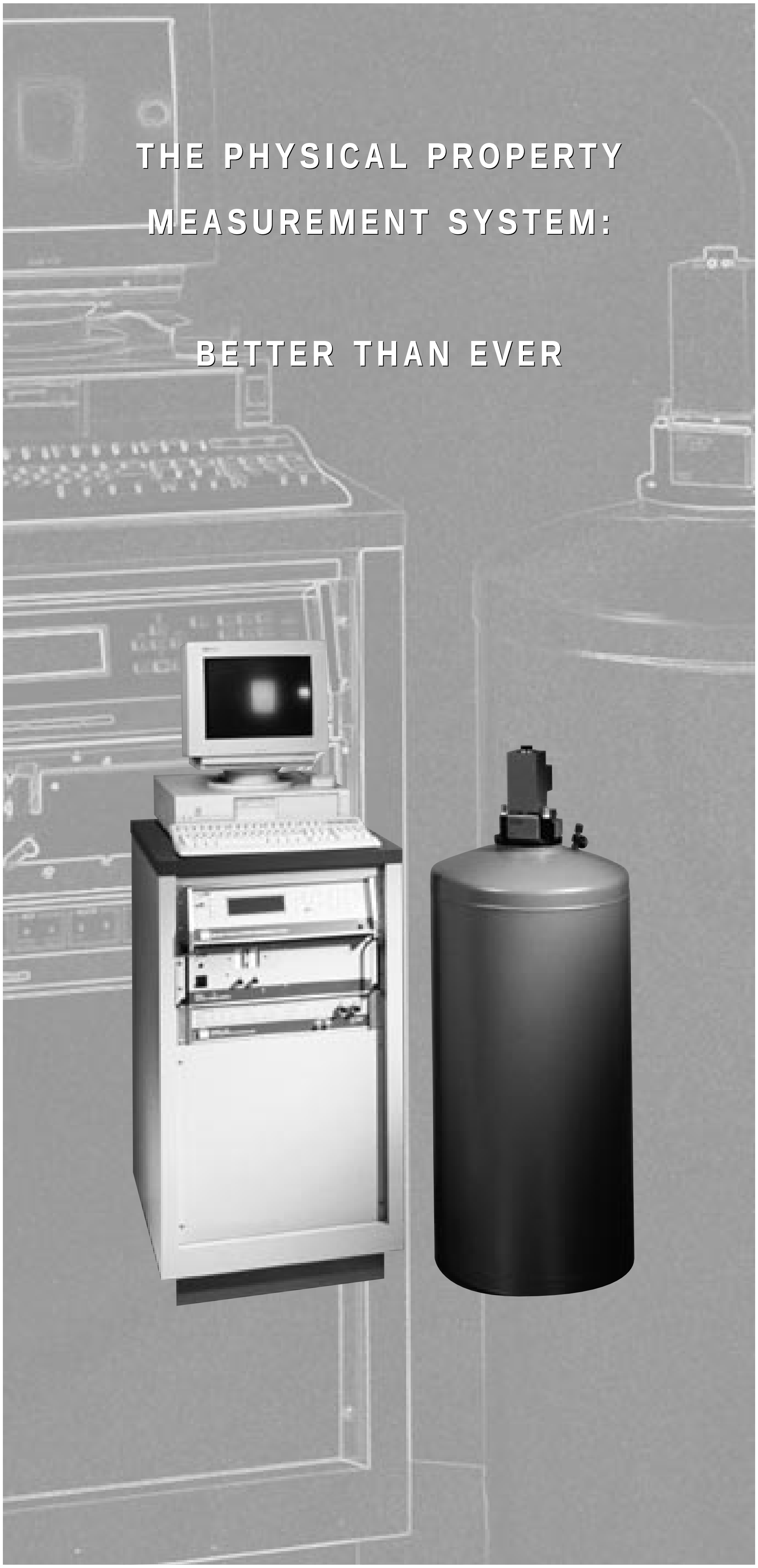
The MRSEC concept incorporates seed funding for emerging areas, a mechanism which gives the centers flexibility to respond to new opportunities. Jerry Woodall explained how Purdue is implementing this concept: “Our seed research program supports young faculty members to test their avant garde ideas. For example, we’re about to start a new seed research effort on gallium nitride, which has been commercialized for blue LED’s and has demonstrated lasing action in research labs. The toughest problem is increasing the doping of the p-type material to lower its resistance. We’re going to launch a totally different approach to that problem. The amount of money required to test the idea is reasonably small, but if it works, the benefit will be tremendous.”

A National Materials Science R&D Network

The NSF conceives of the MRSEC program as the beginning of a national materials science research and development network. “We’re still creating our concept of that network,” said Brage Golding of Michigan State. “It’s becoming common for researchers at one MRSEC to drive three or four hours to use equipment at another. We’d like to institute remote access, so someone in Michigan with virtual control panels and video cameras could participate in an experiment in Palo Alto. Eventually we’d like to broaden the network to include other university labs, industrial labs, and especially government labs, where people have a lot of valuable equipment and are interested in opening up their facilities. I think this broad national materials science network is the real vision which NSF has in mind.”

THE PHYSICAL PROPERTY MEASUREMENT SYSTEM:

BETTER THAN EVER



With a greatly expanded Research and Development team, Quantum Design has been working in full force to develop new options for the Physical Property Measurement System (PPMS) and the Magnetic Property Measurement System (MPMS). Most recently the R&D group has been working overtime to improve and expand the capabilities of the PPMS, making it the most versatile system for magnetic, thermo- and electro-transport measurements available.

With options like Resistivity and the AC Measurement System (ACMS) for performing DC Magnetization and AC Susceptibility already available, the following developments add new dimension to the future of the PPMS capabilities. All of these options, except the 14 T and 7 T Transverse magnets, can be retro-fitted to existing systems.

Heat Capacity

With the Heat Capacity option about to be released, Dr. Randy Black declares, “Our goal in developing the heat capacity option is to provide PPMS users with a fully automated technique for performing a difficult but physically important measurement. We have focused on combining state-of-the-art instrumentation, hardware, and software with a relatively inexpensive and flexible microcalorimeter sample stage design. The option will be fully integrated into the existing PPMS architecture with the same level of usability users have come to expect from the PPMS.”

The user will simply place his sample on the microcalorimeter sample puck and insert it into the PPMS. A measurement sequence may be generated easily and, once activated, the system will perform all the necessary settings and data analysis automatically.

High Field, 14 Tesla

Quantum Design will be introducing a 14 T longitudinal magnet into the PPMS. This NbTi/Nb$_3$Sn hybrid magnet fully charges in less than 20 minutes and has excellent 0.3 G resolution at low fields with the help of Quantum Design's new magnet power supply. This compact, relay-less power supply offers continuous linear charging through zero field with enhanced field setting accuracy.

7 Tesla Transverse Magnet

For researchers needing their magnetic field on the horizontal axis, Quantum Design presents the 7 T Transverse, split-coil magnet. With the charging capabilities of all the other PPMS systems, this magnet position allows for samples to be aligned and rotated around the vertical axis.

High Capacity Nitrogen Jacketed Dewar

This dewar holds 75 liters of LHe and 50 liters of LN$_2$, enabling up to – or even greater than – 2 weeks of hold time before refilling.

Continuous Low Temperature Control (CLTC)

This new capability allows the PPMS to stay below 4.2 Kelvin as long as your dewar helium lasts! Low temperature measurements will no longer be limited by the amount of liquid helium in the reservoir. Smooth temperature control both warming and cooling through 4.2 K is greatly improved.

CLTC includes a newly designed flow impedance that allows a continuous supply of helium into the cooling annulus as needed. Dr. Stefano Spagna, chief developer, explains, "For samples requiring long measurements at low temperatures, such as relaxation measurements or samples expressing extremely temperature hysteretic behavior, CLTC provides an effective means of taking measurements."

AC Transport (ACT)

The ACT provides four transport property measurement techniques in a single package: AC Resistivity, 5-wire Hall Effect, I-V Curve Tracing, and Critical Current.

Designer Kurt Jensen states, "We use an integrated DSP architecture for synchronized, accurate sample excitation and signal read-back. Also, the low-noise preamp features a μ-metal shield which minimizes environmental interference. We pay special attention to mixed signal design considerations in this instrument, carefully implementing both quiet analog electronics and digital signal processing technology. This allows us to produce an extremely low-noise instrument with an AC sensitivity of a few nanoVolts."

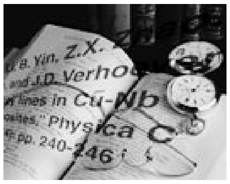
Horizontal Rotator

This precision, stepper motor controlled, horizontal rotator provides a means for measuring angular dependance of electro-transport properties in a field. The stepper motor controls the orientation of the rotator platform through a full 380˚ with a minimum angular increment of 0.05˚. This rotator can give especially meaningful data when used in conjunction with the ACT.

Cantilever Magnetometry

The previous article in this issue explains the benefits and applications of torque magnetometry. Quantum Design's Cantilever will be mounted on the PPMS Horizontal Rotator for sensitive angular dependant measurements. Stay tuned for more information regarding the development of this new option.

Please call your local representative for more details or *visit us at the American Physical Society (APS) Meeting, March 17–21 (booths 423, 425).*



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The service needs of our customers are by far the highest priority of every QD employee. At the same time, many of our customers have ever-tightening budget constraints and frequently have a difficult time paying for necessary equipment repairs. Because of this, we are working to develop easy to follow instructions for troubleshooting and diagnostic routines to help you get your system back up and running.

When contacting Quantum Design for service, whether you are calling your local service representative or QD direct, you can help us help you by giving us as much information as possible, right at the start. Our service engineers are acquainted with a wide range of "typical" problems and you may be surprised how easily we can help you out if you give us all the information we need.

Below I've listed a few suggestions for getting the most of Quantum Design service:

Tell us everything! Whenever possible, it's best if you can email or fax us all of the details of your system problem. This includes the following:

1. What is the system NOT doing right? Is it cooling but not warming up? Does it stop at a certain temperature? Do you only have the problem with certain types of measurements? More detail almost always helps us.

2. When did the problem start? Has the problem been getting worse over time, or did it start suddenly? Did something else occur just before the problem started, like a power outage, a sample lost in the sample space, smoke, or strange smell?

3. Is the problem reproducible? Some problems only occur with certain samples, or with specific measurements.

4. Provide data. Whenever possible, provide data. Frequently customers try to verbally describe a bad SQUID response. This is usually ineffective. However, a plot of the same can tell us a lot about what is happening to the system. In addition, information about the regression factor (MPMS only) is also extremely useful. In any case, if you can show us what is wrong on a plot, it's always helpful.

Many situations that occur with our systems may require the input of more than one engineer or designer. This means that the service engineer you are dealing with may be acting as a liaison between you and one or more other engineers. For this reason, more information and a clear problem description can speed things up considerably.

Let us know how to reach you. We can take service inquiries by telephone, email, or facsimile. However, we will frequently need to fax information to you. So if you call or email us, please include your fax number as well.

Try to deal with one person. Sometimes situations take longer than they should to resolve because customers talk to several different people about the same problem. If you've been working with a service engineer, continue to ask for that person. Of course, if you ever have any concerns or complaints about the service you receive, please let me know right away.

Let us know who you are. We frequently receive emails or faxes from customers who refer to their MPMS system, but with no mention of their institution name or system number. Whenever possible, please include the system number and institution number. The system number is located on the back of the system cabinet. Alternatively, you can provide the probe number. It may not be an exact match, but it can still be helpful.

Let us know what you are using. We tend to get a lot of inquiries with references to a magnetometer, SQUID, or QD system. We sell SQUID controllers, SQUIDs, the MPMS (a SQUID magnetometer) and the PPMS (also a magnetometer, with the ACMS option). Although the MPMS and PPMS are similar in some respects, their differences become significant with respect to service.

A common request we receive is for system schematics. While we do not have a blanket policy against releasing this information, we usually find that we are able to help customers get up and running faster if we help than if they just have a set of schematics in front of them. The QD systems are highly integrated and the schematics for the temperature control system, for example, are not necessarily all that is needed to understand its operation.

Finally, I'd like to encourage anyone to give us suggestions for ways to improve our service. In this day of fee-for-service and service contracts, Quantum Design is bucking the trends and I'd like to keep it that way. QD Service is here to help you get the most of your QD equipment, so we are always open to suggestions!

SERVICE SUGGESTIONS

BY CAROL LIVINGSTON,
CUSTOMER SERVICE MANAGER

In this section of Quantum States, we normally present information pertaining to the service of MPMS or PPMS systems. For this issue, I'd like to take the opportunity to introduce our new European Service Center and give a few tips on how to get the most out of our service team.

The biggest change to our service operation is our new European Service Center, located in Darmstadt, Germany. This new service center is established with the cooperation of our German distributor, L.O.T. - Oriel GmbH. Opened in June 1996, this service center provides telephone, fax, and email support for Quantum Design customers. Although most major repairs still need to be performed at QD San Diego, this service center is stocked with service equipment and inventory items to get replacement equipment to you quickly. Of course, our trained technicians will be able to help with all troubleshooting and installation services. Contact information for the service center is:

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c/o L.O.T.-Oriel GmbH
Laser Optik Technologie
Im Tiefen See 58
D-64293 Darmstadt, Germany
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In addition to our European Service Center, of course, we have our San Diego, California headquarters and another major service center in Japan, at the offices of Indeco Sales and Service.

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