January 2006

UCF College of Optics and Photonics
CREOL & FPCE

HIGHLIGHTS

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INSIDE

Creating the **Future** of OPTICS and PHOTONICS

Academics
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Construction Begins on CREOL Building Expansion!

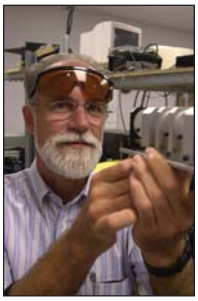
The much anticipated start of Phase I of the expansion of the CREOL building officially began in mid-October. As the December holidays arrive, ground preparation and modifications to the back entrance to the current CREOL building are well underway. This 21,000 ft^2 3-floor expansion will add much-needed office, laboratory, instructional, and conferencing space to the current 83,000 ft^2 building, which was first occupied just 10 years ago in 1995. Construction is scheduled for an occupancy date of the first week of November 2006.

The addition will be an extension to the north side of the CREOL building, with an elevation similar to the one shown in the figure. The first two floors will be fully built out, but the third floor will be just a shell with minimal lighting and air conditioning. The third floor will be built out later with labs and offices similar to the first two floors when sufficient additional funding is obtained (~$800K is needed). The new space will also provide space for a small addition to UCF's business incubator for UCF partner companies who need daily interaction with CREOL faculty and students. Phase II of our building project plans will construct a similar 3-story expansion on the east side of the current CREOL Building, giving us a total of 35,000 ft^2 of additional office and laboratory space. But we need your help, to enable this vision for our future facilities, to become a reality.

Funding for the new addition has been provided by several generous sources: Florida Photonics Center of Excellence ($1M - state of Florida funds), US Department of Commerce Economic Development Administration ($1.5M), Florida High Tech Corridor Council ($750K), UCF Office of Research and Commercialization along with UCF Provost's funds ($1.6M), gifts from companies and individuals ($100K, including a 1:1 Florida state match). In principle this leaves us only $300k short; however, the 3rd floor is not being built out and there are no funds for furniture or other facilities such as projection displays. We have an active capital fund campaign that will continue at least through 2006 to raise funds for the completion of this Phase 1 expansion, and to establish a fund for a future Phase 2 expansion. This would complete the available expansion of the CREOL building. Private gifts to our building fund are eligible for a 1:1 match from the Florida Alec P. Courtelis

Please see **CONSTRUCTION**, page 5

Dean's Corner



Eric W. Van Stryland

My duties as President Elect of the OSA have kicked in with some fun trips to distant lands, which I will outline in a minute. Such trips and other duties are taking time away from my duties as Dean of the College, so it is important that I rely on others here to 'hold down the fort' in my absence. Luckily, we have a very understanding and supportive faculty and staff, and with some recent hires and changes in staff everything will run smoothly when I am out of the office.

These staffing changes include the elevation of David Hagan to Associate Dean of the College, Jim Pearson to Director, Research and Administration, Mark Wagenhauser to Associate Director, Research Program Services and Business Operation, and Courtney Lewis to Assistant Director, Academic Support Services and Marketing Communications. These changes better reflect their jobs and will further enable the College to grow and serve its faculty, researchers, students, and external partners. Now back to my OSA duties!

I had the privilege of initiating a new student chapter in Sao Carlos, Brasil (Portuguese spelling!) and then traveled to Recife to lecture at a conference put on by another OSA student chapter. Both were great fun. The students in Brazil were great and we already have had visitors from there! There should be an article coming up in Optics & Photonics News in the next few months on 'Optics in Brazil'. Lots of us from CREOL went to Tucson for the annual Frontiers in Optics meeting where I got my picture taken with the 3 new Nobel Laureates (all of whom I know), and then I went on to talk to a regular local OSA section in Boulder.

On the faculty front, we continue to selectively expand our research capabilities into new and emerging photonics areas. During this next year, a primary goal is to hire an expert in "Biophotonics" and, thanks to the Florida Photonics Center of Excellence; we have endowment funds to hire this person. George Stegeman is leading our search committee. This year, we expanded our Nanophotonics capabilities by hiring Dennis Deppe from the University of Texas at Austin as the FPCE Eminent Scholar Chair of Nanophotonics. Dennis has just joined us after we made major renovations in our building to accommodate his and faculty member Winston Schoenfeld's Molecular Beam Epitaxial (MBE) growth chambers. These new instruments and Dennis' and Winston's expertise provide us the unique capabilities to grow quantum dot materials from III-V materials, nitrides, and oxides for LED's and lasers. A new program funded by DARPA (Super High Efficiency Diode Systems, SHEDS) will utilize these capabilities to build world record wall plug efficiency diode lasers. Another new DARPA program in diode laser technology was recently awarded to Leon Glebov and coworkers: Architecture for Diode High Energy Laser Systems (ADHELS). The goal of this program is to develop high power diode laser systems by beam combining using Leon's volume Bragg grating technology.

I must praise the faculty some more for their continued success at attracting research funding from government and industry. This past fiscal year (ending June 30, 2005) they received $16,856,215, of which $4,414,758 (26.2%) came from industry partners in 70 separate awards. And this fiscal year is off to a good start: in the first two months (July & August), COP faculty received 15 new funding awards totaling $2,128,413, of which $571,413 (27%) came from industry partners. The continued strength of the industrial partnership support is in part due to the success of our Industrial Affiliates program run by Jim Pearson. These affiliates are listed at the end of each of our Highlights. If your company is not a member, they should be! For information, see our website at http://www.creol.ucf.edu/people/affiliates/.

We are beginning a redesign of our website and I would welcome suggestions as to how to make it better. Almost all of our prospective students learn about us through the web – and I guess that almost everyone else does too! So it is important that we get this right!

We are also searching for a new chair of the UCF Department of Physics. I am the chair of the search committee and want to stress the importance of our having strong science and engineering departments on our campus. If you know of potential candidates, please let me know. We began looking at files on November 1. To better acquaint ourselves with the physics faculty, many of whom are new to UCF, we recently invited the Physics faculty to visit CREOL. I gave an overview of the College and CREOL, and the student organization CAOS (CREOL Association of Optics Students) gave a tour of the labs. A reception was held afterwards, allowing the two faculties to get to know each other better.

Virendra "Viny" Mahajan visited here for several weeks this fall from Aerospace Corp. to give a course on a topic in which he is a world expert: aberration theory.

We have broken ground on the CREOL building addition project this month, with a completion date of November 2006. The additional 21,000 sq. ft. of space in a 3-story structure is dearly needed. We are still actively seeking donations to fund the build-out of all three floors of the addition. Information about and drawings of the addition can be found on our website at http://www.creol.ucf.edu/About/NewBuilding.htm. A link to a donor form is also on this web page.

Research Focus:

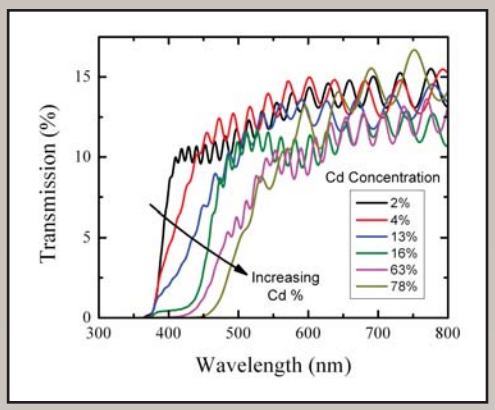
Characterization of CdZnO compounds for UV/Visible Optoelectronics

by *Winston Schoenfeld*

Zinc Oxide-based (ZnO) compounds have gained significant interest in the scientific community due to their potential impact in the wide band gap arena. ZnO has been shown to have an exciton binding energy of ~ 60meV, roughly twice that of GaN, enabling epilayers to maintain relatively efficient electroluminescence up to temperatures of 650K. Prior research has demonstrated the ability to tune the band gap of ZnO to higher or lower energies by alloying with Mg or Cd, respectively. This has opened up the potential for heterostructure devices offering high efficiency optical emitters and detectors.

Through joint efforts with SVT Associates in Eden Prairie, MN, we have demonstrated CdxZn1-xO epilayers with Cd concentrations as high as 78%, as verified by Rutherford backscattering spectroscopy (RBS) and secondary ion mass spectroscopy (SIMS). X-ray diffraction (XRD) data verified that the epilayers were of hexagonal phase and contained a strong 2θ peak between 33.5° and 34.23° for CdxZn1-xO epilayers of various Cd concentrations of up to 78%. XRD data is void of any cubic phase related peaks indicating that a metastable wurtzite structure of CdxZn1-xO was maintained throughout the Cd concentrations studied.

Transmission spectroscopy, shown in Figure 1, was used to determine the relative shift in the band gap energy of CdxZn1-xO as a function of Cd percentage. By increasing the Cd concentration up to 78%, the band edge was successfully shifted by ~100 nm (600 meV). Additionally, there is no indication in the transmission data of phase segregation of Cd-rich regions. This is in great contrast to the observations of other groups, signifying that we have identified an optimal growth region for high Cd incorporation without phase segregation. To verify the potential application of CdxZn1-xO compounds in optical devices throughout the visible range, cathodeluminescence (CL) data was taken from the CdxZn1-xO epilayers. Figure 2 shows the spectral data from the CL evaluation, indicating the apparent shift in wavelength from the violet (405nm) to yellow (580nm) regions for increasing Cd incorporations of up to 29%. The FWHM of the emission ranges from 35-37 nm as would be expected from a typical bulk film emission. Corresponding optical images of the CL emission are also given in Figure 2.



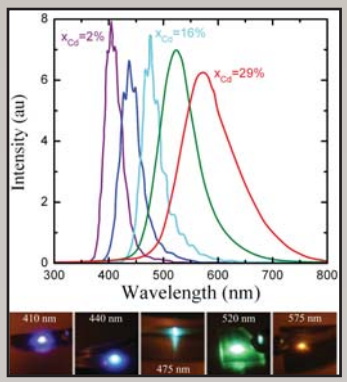


Figure 1: Shift in band edge as a function of Cd concentration.

Figure 2: CL data and corresponding optical images from various CdxZn1-xO epilayers.

This research has demonstrated the real potential of CdxZn1-xO as an alternative material system for visible and UV optoelectronics. Future efforts are under way to better characterize the optical properties of the CdxZn1-xO epilayers and to develop heterostructures for higher efficiency light emission.

Dr. Winston Schoenfeld is an Assistant Professor of Optics and leads the Nanophotonics Device Group
http://npdg.creol.ucf.edu/

Fall 2005-2006 College of Optics and Photonics Fellows

Student Name	Advisor
Abdullah Demir	Deppe
Amy Thompson	Schoenfeld
Dana Kohlgraf	Kik
Davorin Peceli	Hagan
Dimitrios Mandridis	Delfyett
Sidhartha Pandey	Boreman
Thomas Owens	Dogariu
Timothy McComb	Richardson
William Hageman	Bass

Student Name	Advisor
Kaia Buhl	Johnson
Florian Fournier	Rolland
Curtis Rosenow	Glebov
David Shelton	Boreman
Mike Marquez	Deppe
Steven Frederick	Boreman
Clarisse Mazuir	Schoenfeld
Michael Hemmer	Richardson
Syed Reza	Riza

Research Focus:

Micro-Sculpting Using Phase Masks For Projection Lithography*

by *Eric Johnson*

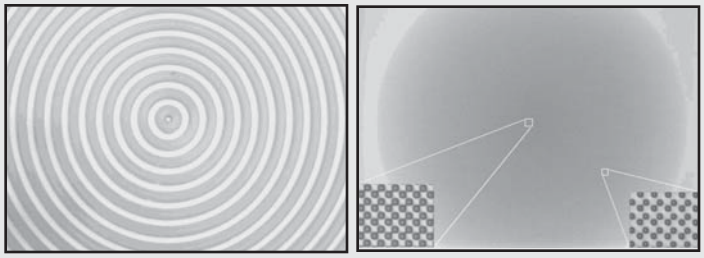


Figure 1. One and two dimensional phase mask designs for a positive micro-lens

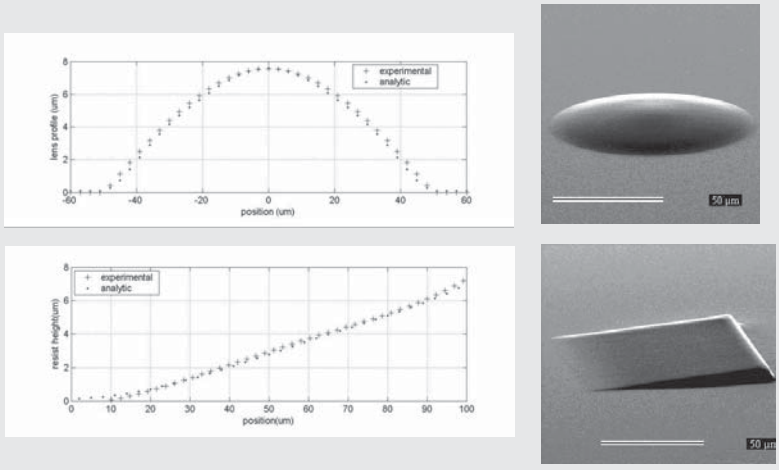


Figure 2. Curve fit and SEM images of a micro-lens and micro-prism

In the field of micro-optics, refractive elements such as micro-lenses are difficult to fabricate using photolithographic techniques. Photolithography has been developed primarily for fabricating binary structures in photo-resist. The binary type of resist profile has been researched and optimized extensively for the past twenty years in order to reach the highest possible level of resolution, but this conventional photolithographic process is unsuitable for the continuous relief profiles required for refractive micro-optical elements. In the micromachining of micro-optics, a special technique is required to create continuous analog resist profiles for analog micro-optical elements such as micro-lenses and prisms.

There are currently three methods to make analog profiles in optical stepper systems, two of which are highly restrictive and cost prohibitive (half-tone and gray scale masks). The gray-scale and half tone mask techniques use amplitude masks to control the intensity distribution on the wafer plane. Micro-sculpting using phase masks utilizes the properties of phase gratings to control the 0th order light passing through the projection imaging system used to fabricate the optics. By changing the duty cycle of the phase grating on the mask, it is possible to vary the intensity reaching the wafer plane accordingly. The result of this method is an analog profile in thin or thick photoresists. By utilizing phase rather than amplitude, it is possible to avoid the edge scatter caused by the amplitude changes and overcome numerous other issues, including depth of focus.

The critical design portion for the phase mask is in the duty cycle representation. Realizing that the changing duty cycle will directly correlate with a changing intensity on the wafer plane it is necessary to break down the desired topography into a one or two dimensional grating (Fig 1). The filling fraction of each period in that grating determines the amount of light passing through the system. This intensity determines the thickness variation of the developed photo-resist, dependent on the exposure dose and time. By writing the phase mask with a high resolution electron beam system, it is possible to change the filling fractions in the smallest possible increments, to create the most accurate phase masks and further facilitate complex topographies. It is often beneficial to first characterize the photo-resist in terms of response to the incoming light to utilize the greatest available thickness variation. This phase mask technique provides flexibility in terms of thickness and types of resist that are not accommodated by the amplitude based techniques in that a single mask design may be used for thin or thick resists regardless of the difference in the optical response of the resists.

A positive micro-lens and micro-prism were the first elements designed and fabricated. After fabrication, the one-dimensional surface profile from a numerical analysis was overlaid with the one-dimensional plot from the surface fitting of both elements and found to match with less than 5% error (Fig. 2). Other elements have been fabricated in both thin and thick photo-resist for a variety of applications (Fig. 3). After fabrication, the elements are then transfer etched into the substrate with a selectivity to accommodate the final profile. Micro-sculpting using phase masks for projection lithography can be applied to arbitrary three dimensional surface topographies for applications ranging from

Please see **JOHNSON**, page 5

Johnson, from page 4

micro-optics to BioMEMs. Moreover, this process provides an extremely efficient and cost effective approach to fabrication, while utilizing standard photolithographic methods of fabrication used in the chip industry today. •

Dr. Eric Johnson is an Associate Professor of Optics and leads the Micro-Phonotics Lab

(http://mpl.optics.ucf.edu/)

*patent pending

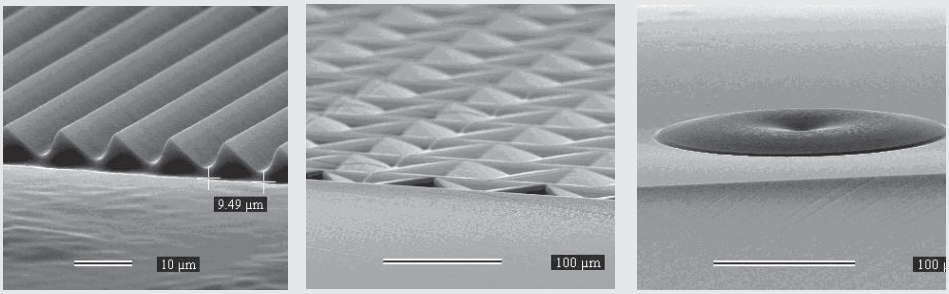
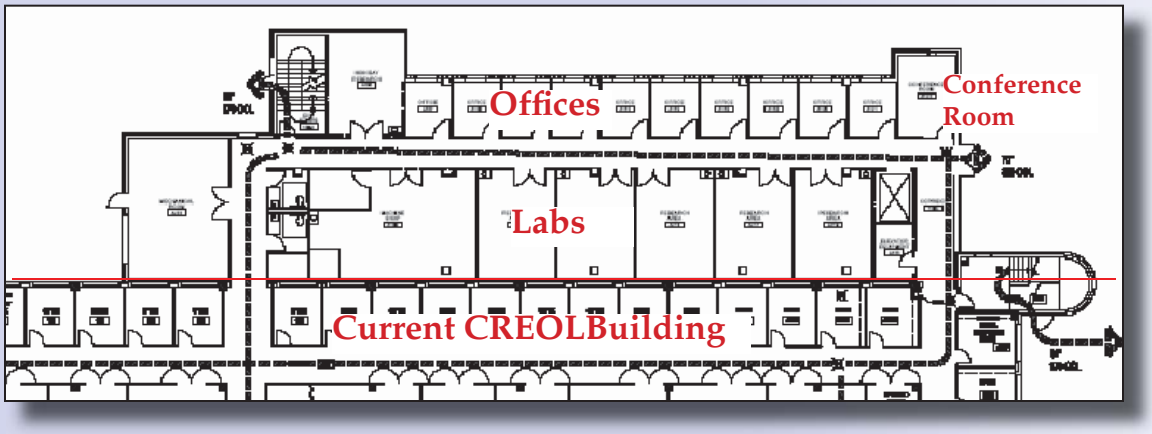


Figure 3. SEM images of a blazed grating, trihedral array



Construction, from Cover

Facilities Enhancement Challenge Grant Program. We are urging all of our partners, friends, and colleagues to direct their donations for the next 12 months to our Facilities Enhancement Fund. For further information, including naming and donor recognition opportunities, please see our website (http://www.creol.ucf.edu/about/NewBuilding.htm) or contact us via phone or email.

In addition to our capital campaign, we have other funds, held for the College's use by the UCF Foundation, Inc., to which donors can direct their contributions to help provide graduate fellowship funding and/or equipment and other support for the College's research program. Monetary gifts have so far provided three named fellowships: the Schwartz Fellow, the Northrop Grumman (formerly Litton) Fellow, and the Suchoski Fellow, as well as assistantships to support student research. The current holders of these fellowships are Amy Thompson (Schwartz) a student in Prof. Winston Schoenfeld's research group, David Shelton; (Northrop Grumman), a student in Prof. Glenn Boreman's research group; and Michael Marquez (Suchoski), a student in Prof. Dennis Deppe's group Other major contributors to student support are Presidential Doctoral Fellowships and Trustees Doctoral Fellowships, which are competitive awards provided by the Office of the President and the UCF Board of Trustees to superior graduate students who are newly enrolling at UCF in one of its doctoral programs or tracks. Out of the 25 – 30 of Presidential and Trustees fellowships awarded this year, the College of Optics and Photonics received four.

This additional student support is made possible through individual faculty members' contracts and grants; but largely through the philanthropy of industry partners and pioneers who saw the need to support education in optics and lasers and, more importantly, wanted to be part of the success of optics research at the University of Central Florida. If you or your company would like to learn more about donation and recognition opportunities for supporting our programs and students, including programs that will match your contributions, please contact Jim Pearson, Director, Research and Administration (407/823-6858; jpearson@mail.ucf.edu).

Amy Thomspson
Schwartz Fellow
B.S. Illinois Institute of Technology
Advisor: Winston Schoenfeld
Research Area: Nanophotonics

Please see Named Fellows, page 6

College of Optics and Photonics Named Fellows

Dana Kolhgraf
Trustees Fellow
B.S. The Ohio State University
Advisor: Pieter Kik
Research Area: Nanophotonics

Timothy McComb
Trustees Fellow
B.S. Univ. of Arizaona
Advisor: Martin Richardson
Research Area: High Powered Lasers

Thomas Owens
Trustees Fellow
B.S. University of Alabama at Huntsville
Advisor: Aristide Dogariu
Research Area: Photonic Diagnostics of Random Media

Michael Marquez
Suchoski Fellow
M.S. Stanford University
Advisor: Dennis Deppe
Research Area: Nanophotonics

William Hageman
Trustees Fellow
M.S. Kansas State Univ.
Advisor: Michael Bass
Research Area: Solid State Laser Design

David Shelton
Northrup Grumman Fellow
B.S. Univ. of Evansville
Advisor: Glenn Boreman
Research Area: Infrared Systems

Faculty and Student News

Faculty News

Emeritus Professor **Bill Silfvast** has completed the last year of his phased retirement and is now making wine in NAPA valley. In spite of this new direction in his career, Bill plans to continue working with Martin Richardson on optical lithography, so we will be seeing him here in the future.

Dr. Michael Bass, Professor Emeritus of Optics was named as a Life Fellow of the Institute of Electrical and Electronics Engineers, Inc. (IEEE).

Eric Van Stryland is now one of the most highly cited researchers in optics,as determined by ISI, joining George Stegeman from COP/CREOL/FPCE.

Dr. Peter Delfyett was highlighted in the October issue (pg 18) of Florida Trend magazine as one of the "trendsetters" for university research and tech transfer in Florida. The full article can be viewed online with a nice photo at http://floridatrend.com/issue/default.asp?s=3&a=5628&d=10/1/2005.

The October issue of OPN (pg 46) has both **Peter Delfyett and Clara Rivero's** pictures. Note on the same page the announcement of the Handbook of Optics editorial board meeting held here at CREOL on Oct. 10. Mike Bass is the editor in chief and Eric Van Stryland and Guifang Li are both editors. Also see the COP/CREOL/FPCE ad for graduate students on page 59.

Student News

Yung-Hsun Wu's paper from Shin-Tson Wu's group was highlighted as the cover page for the Sept. 5 issue Optics Express (http://www.opticsexpress.org/).

Clara Rivero has been selected this year as the winner of the American Ceramic Society's Norbert J. Kreidl Award for Young Scholars recognizing excellence in research. This is the highest award that the American Ceramic Society awards to students.

Graduate student Supraja Murali won one of 5 awards from Optical Research Associates this year. She works with Dr. Jannick Rolland.

Graduates Summer 2005

Avni Akcay
Ph.D. Optics
Adv: Jannick Rolland

Muzamil Arain
Ph.D. Optics
Adv: Nabeel Riza

Isao Matsubaru
M.S. Non-Thesis

Brian Monacelli
Ph.D. Optics
Adv: Glenn Boreman

Frank Quinlan
M.S. Non-Thesis

Ying Zhou
M.S. Non-Thesis

Fall 2005

Nicholas Barbieri
M.S. Physics
Adv: Martin Richardson

Costin Curatu
M.S. Non-Thesis

Gilad Goldfarb
M.S. Non-Thesis

Jared Hudock
Ph.D. Optics
Adv: Demetri Christodoulides

Sajjad Khan
Ph.D. Optics
Adv: Nabeel Riza

Jun Li
Ph.D. Optis
Adv: S.T. Wu

Supraja Murali
M.S. Thesis
Adv: Jannick Rolland

Clara Rivero
Ph.D. Optics
Adv: George Stegeman
Kathleen Richardson

Haiying Wang
Ph.D. E.E.
Adv: S.T. Wu

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Rini Technologies
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Siskiyou Design Instruments
SPIE- The Int'l Society for Optical Engineering
Spiricon
Technical Manufacturing Corp.
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Veeco Instruments

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Jim Pearson	407-823-6858
Diana Randall	407-823-6834