FIAP Newsletter

Spring 2012

American Physical Society Forum on Industrial & Applied Physics

Contents

Comments and questions can be sent to fiap_newsletter@aps.org.

Opinions expressed represent the views of the individual authors and not the American Physical Society or author's employers.

Letter from the Editor (fiap_newsletter@aps.org)

Welcome to the resurrected newsletter of the Forum on Industrial and Applied Physics. Over the course of the Summer of 2011 FIAP's Chair, Ernesto Marinero, formed a committee headed by Bob Celotta to advise the FIAP Executive Committee whether a newsletter would be a good vehicle to better serve the needs of our Forum. The Celotta Committe's report was unanimous in recommending that a newsletter not only was valuable to our membership but also a critical vehicle to more effectively communicate between the three major communities that comprise FIAP's membership: Industrial Physicists, National Lab Members and the Applied Physics Community in Academia. As the largest APS forum, the FIAP Executive Committee (ExComm) felt it important to have a way to communicate with our members. Twice a year at least, based on our Membership's needs, we will publish forum announcements and provide original content of interest to the FIAP community. Regular sections will include a discussion of an area of forum interest from industrial, national lab, and academic perspectives; career related articles for graduate students and physicists moving into areas outside academia where most of physics graduates are to-date employed. FIAP recognizes that in the 21st century, physicists are mostly employed in occupations outside conventional physics careers and that there exist an opportunity through our newsletter to help them be better equipped to be successful in working in multidisciplinary teams that often embrace diverse scientific disciplines and engineering skills. The newsletter will also contain forum announcements; and a letters section which should foster diverse perspectives on the needs of an early 21st century physicist. Three considerations guide the editorial board's choice of feature articles.

First, that FIAP members come from three distinct classes of organizations that need to collaborate to achieve their missions. Collaborations across industry, national labs, and academia fundamentally differ from multi-disciplinary or cross-university research common among the APS's academic members in that the incentives of each institution radically differ from one another. Academic researchers prosper through their publications and the grant or license revenue they bring their institutions. National labs measure their success by achieving a set of federally determined, often commercially oriented milestones. Industry survives by selling at a profit. Those three groups are bound together by their mutual needs: industry needs the understanding and resources of universities and national labs, and these latter two need industry to validate the applicability of their work. Tension between the three arises from issues of secrecy and revenue sharing (e.g. licensing). This newsletter will provide a forum for discussing how researchers build these collaborations and balance their differing goals.

The second consideration guiding the editorial board is that the employment diversity of FIAP makes us best situated to help inform young physicists about careers. Every month will feature a section on careers and job seeking. APS members have written a great deal about the decline of the industrial labs and decrease in US support for research; however, our profession is more threatened by the 77% of students who joined APS in 2006 and have since left our community (private communication, Trish lettieri, APS). While APS attrition and research funding are linked, these 2900+ physicists who left the APS are likely employed and can help show today's students compelling career options.

Finally, the editorial board believes that physicists can play a significant role in re-establishing manufacturing in the developed world and the US in particular. Our manufacturing-heavy editorial bias demonstrates itself in this issues' discussion of 1366 Technologies and IBM.

When last published in 2007 under the editorship of Alexander Bratkovski, Facebook had less than 1/20th the user base it has today and iPhones had just hit retail shelves. It might be easy to dismiss the publication of a static newsletter in 2012 as at best anachronistic. More harshly, one could view this newsletter's resurrection as yet another instance of middle-aged men (regrettably, we editors all carry XY chromosomes) exploiting the popularity of the undead. As we look forward to our future issues, the editorial board wants to hear from you. Which articles have value? Do you want the ability to comment? Is a twice-yearly newsletter the right format to carry the content we propose, or do readers want to see content as it is produced through their Facebook or LinkedIn news feeds?

Don't miss the FIAP business meeting

Tuesday, February 28 from 5:45 to 6:45 pm, Room 258C

New Fellows will receive their credentials, the new FIAP Executive Committee will be introduced, the new Chair's outline of plans for 2012 will be presented, refreshments and more. Expect some surprises at the meeting, so don't miss it.

Building successful academic-industrial collaborations

It is generally agreed that academic/industrial collaborations improve the nation's capacity for intellectual and economic growth. But what does it take to have successful academic/industrial collaborations and what are the avenues available for forging them?

One obvious path is the National Science Foundation's GOALI ("Grant Opportunities for Academic Liaison with Industry") initiative that aims to synergize university-industry partnerships by making funds available to support an eclectic mix of industry-university connections. Then, there are various industrial consortia such as the Semiconductor Research Corporation (SRC) or The Petroleum Research Fund with similar goals but targeting specific industries. And there is a possibility of direct interactions with a particular company.

The key to any successful partnership is that all parties involved should get something out of it. And since, depending on where one is, the metric of success changes, it is important to understand the difference in perspective between industry and academia.

A rather personal perspective, based on collaboration between the IBM T.J. Watson Research Center and the Physics Department at The University of Texas at Austin, follows below. The experience is sufficiently typical to be of interest to a broader audience.

Academic perspective

In a Research I University, faculty are judged on teaching, service, and research. In their 2000 edition of the classification, the Carnegie Foundation renamed the "Research I" category to "Doctoral/ Research Universities-Extensive" to "avoid the inference that the categories signify quality differences." But it is still an institution giving high priority to research, granting more than 50 doctoral degrees a year, and generating annually over $40 million in federal support. From the perspective of this metric, when looking at a possibility of industrial collaboration, the enhancement of research, education, and/or service missions is of paramount interest.

Research

- Expertise. Very often a University does not identify a specific expertise needed for a multidisciplinary project, or it may be difficult to access that expertise in a timely manner; while a large industrial lab typically would have a group of world-class scientists and specialized tools in a specific area. Interacting with these scientists is a tremendous help in solving difficult problems.
- Prestige. The fact that one's work is helpful to US industry carries certain cache in academic circles. In our funding proposals, we all mention that the research will help the nation's competitiveness in the international market place, but it is often difficult to demonstrate a direct connection between the two.
- Access to techniques. The need to access expensive or rare experimental techniques is a major motivation. Electron microscopy is one example, transistor process flow is another.
- Funding support directly (company support) or indirectly (GOALI or SRC). Research is a very expensive business. And raising funds in support of one's research program is a major effort. In addition, an existing joint program with the company makes a proposal stronger. However, one has to make it absolutely clear why the company cannot underwrite the entire project, and external funding is necessary.

Education

- The educational benefit can be huge. Simply interacting with a group of people who really care about one's work is very stimulating. It also provides a student an often missing perspective of how her or his work fits in the "big picture'. Also, as the AIP statistics shows, the vast majority of Physics Ph.D.s get jobs in industry. Yet, most of the students have no experience with industrial research. Exposure to industrial research undoubtedly helps students to have an informed approach to career choices. Some hate it right away, while others embrace it. Either way, they are better equipped to deal with their future.
- To some students, industrial internships offer the best way to experience applied research. To many, it is an eye-opening experience, they are not treated as students but as individuals with advanced degrees who are subject-matter specialists. It also feels good to be well paid for one's work.
- Internships and industrial experience in general are a plus for students looking for a job. Hiring managers often overlook physicists in favor of those with engineering degrees whose training is perceived as being more relevant. Including internships in a CV and a recommendation letter from industry may help overcome this prejudice.

Service

- Service beyond one's University is highly appreciated. Working relationships with members of an industrial lab provide a member of the academia with exposure that allows one to get involved with various industrial and research policy panels, think tank groups, etc.
- The benefit of an industrial internship to a student in the process of job hunting has already been mentioned. An average faculty in a Research I university graduates approximately one student a year. Assuming a career span of thirty years, this results in a sizable group of individuals who obviously cannot all end up in a university environment. A steady stream of physics Ph.D.s towards industry is very healthy. Many enlightened Physics departments cherish and promote connections with their graduates moving up through the industrial ranks and this has a tangible positive effect.
- In my experience, strong industrial ties help with the recruitment of US students many of whom are uncertain about choosing a career with a mediocre income. Michael Lubell, the APS Director of Public Affairs, has often commented on the lure of Wall Street and expressed optimism for the future of physics in view of recent financial troubles. His point is well taken, but a successful industrial career may be just a possible alternative!

Industrial perspective

Companies at the forefront of cutting edge research and advanced technology development have a long standing interest in collaborations with Research I universities since such partnerships serve many important functions. Firstly, Research I universities by their very nature and academic profile tend to be institutions wherein many of the early ground breaking ideas for a new advanced technology are first envisioned. However, there tend to be many such ideas that are brought forth and a university eco-system serves as an ideal place to whet out many of these concepts, thereby narrowing down the options that could be considered for adoption. By virtue of direct collaboration with the university, industry can thereby mitigate pathfinding and exploratory research expenses and get early access to such an advanced technology. Secondly, universities present the opportunity for unique capabilities and expertise (such as MBE growth of oxides), which serves as the perfect compliment to the capabilities within the industrial laboratory (such as state of the art clean room facilities for device fabrication). Thirdly, university collaborations provides industry with access to a pool of qualified students. Industrial interaction can be in the form of summer internships, which enable the student to work in an environment where their academic knowledge can be adapted to address real life industrial problems. On the other hand, internships also serve as an opportunity for the industrial hiring managers to understand the skills and aspirations of the new breed of students and accordingly enable an organizational climate that can attract the best and brightest amongst the graduating pool of students

Industry-university research collaboration thrive in an environment where there is a mutual appreciation of the missions and success metrics of both organizations. Inevitably the business interests of both organizations must be reconciled and one of the key hurdles to initiating a successful university-industry collaboration is the resolution of intellectual property rights for both parties, in terms of (a) whether patents are solely owned or jointly owned and (b) the rights to license and sub-license to third parties. No one model fits all collaborations and expectations must be scaled to the level of interaction and industry funding as the IP terms are resolved up front of the formal collaboration.

Alex Demkov is Professor of Physics at the University of Texas at Austin and Vijay Narayanan is a Manager of High-k/Metal Gate Process Development at the IBM T. J Watson Research Center both are APS Fellows.

Leveraging industry, academia, and government to create green jobs: an interview with Craig Lund of 1366 Technologies

Craig Lund is the Vice President of Business Development for 1366 Technologies. 1366 Technologies is a solar energy start-up backed by private investors with close ties to MIT. The *FIAP newsletter* had the opportunity to speak with Craig upon his return from 2 ½ weeks of business travel in Asia. [*Editor's note: questions and answers have been edited for brevity and clarity].*

FIAP: Can you tell me a bit about 1366 Technologies?
Craig: We really are the stereotypical university start up. We grew out of Prof. Emanuel Sachs lab at MIT. His lab was originally focused on solar, then moved to 3D printing, and then refocused back to solar after September 11th . MIT is very sophisticated, flexible, and commercially minded in how it lets companies grow from within it. Back in 2007 Prof. Sachs co-founded 1366 with an MIT graduate. With their own and MIT's connections in industry they rounded the company out with a world class technical team focused on new machine and process designs for silicon photovoltaics. Our target is to get the price of conventional solar down to the price of coal to put us beyond the debate about solar subsidies so that solar can scale rapidly in the US and abroad. Our approach at the time was unique in that we were focusing on silicon photovoltaics. Our philosophy is that silicon will be the dominant material system within photovoltaics and we want to innovate around processes that dramatically reduce manufacturing costs in that supply chain. We did not want to invent in an unproven material system.

FIAP: What is your business model?
Craig: We have two key areas of technology. One is around high efficiency solar cell architectures. Here we are working on process and machine designs that dramatically increase the efficiency of polycrystalline solar cells through improved texturing and metallization. We plan to sell equipment to solar manufacturers. The other product focus is a wafer technology we call Direct Wafer. Direct Wafer is a way to form the substrate at much lower cost. For this work we were recently awarded a DOE loan for $150 million to scale up the process. [Editor's note: Direct Wafer is a technique to form polycrystalline silicon wafers suitable for downstream PV processing without having to saw the wafers from a larger block of material. It is a "kerf-less" process, in that there is no kerf loss from the material removed by the saw.] Our products will be wafers.

FIAP: What underlying technologies/building blocks do you rely on?
Craig: On the texturing what we have developed is a very low cost masking process. It has nothing to do with photoresist or anything like what is done in semiconductor. It allows you to create structured surfaces on silicon substrates like the honeycomb structure on our web site [http://www.1366tech.com/technology/self-aligned-cell/].

FIAP: So when you say texturing, is that just for the metallization or for light trapping?
Craig: The texturing is all about light trapping, but the metallization keys into that. The honeycomb structure and the metallization play together. Being able to create new surface topography where you can define exactly where the honeycomb structures exist and define where the metallization exists stems from the masking technology. The combination of the two is what we call the Self Aligned Cell.

FIAP: When you talk about kerf-less, is there an underlying technology like the low-cost masking?

Craig: The way traditional substrates are made is a very inefficient batch process that has been around for decades. One takes high impurity silicon, melts it in a directional solidification furnace, and forms a large ingot that gets cut into bricks, the bricks get bonded to glass plates and then sawed into wafers. We take the same silicon feedstock and melt it within a machine that forms the wafers one at a time. Instead of separating the steps of purification and wafer forming, we do both at the same time. We give the right size and right quality polycrystalline silicon in a semi-continuous process.

FIAP: So your technology is about controlling the time/temperature relationships?

Craig: Yes. The way to envision it is that we have a way to freeze and remove a thin layer of silicon from the top the melt.

FIAP: So when you think about these two technology areas, how did you originate the idea to focus on these areas?

Craig: The big insight for the company was the belief that silicon would win. Once we had that insight, where could we focus–especially as a small company that has to produce something of value pretty quickly–what areas of the supply chain could we focus on that fits our skill set. We are heavy on mechanical engineers, so our core strength is on machine design and process. Then we addressed what types of choke points on cost exist in the supply chain.

FIAP: You started by evaluating the supply chain. You did not have a technology looking for an application?

Craig: Right. The texturing is very simple. A lot of the efficiency difference between monocrystalline and multicrystalline cells is because there is no cost effect texturing process for multicrystalline cells. For monocrystalline cells you have anisotropic pyramidal etching which gives very nice light trapping with a KOH etch. For multicrystalline, this just doesn't exist. We thought [back in 2006] that if we could provide low-cost light trapping for multicrystalline then we would have something of high value. Similarly for the metallization, the quantity of silver that is applied probably makes it the highest cost component of cell fabrication these days. Silver is probably ⅓ to ¼ the cost of producing a cell today. So we thought that a technology that enabled you to move from silver to copper, and that could let you use less of everything, would have value to cell manufacturers. On the wafer side, the industry has been frustrated for 30 years that in the multistep process to form a wafer not only do you have 10 machines to make the process work, you also waste about 50% of the silicon feedstock in the process. Reducing the waste and the amount of equipment brings a lot of value.

FIAP: What does growing mean for 1366? What will 1366 look like when it is successful?

Craig: On the texturing and metallization, it means that in the next few years several top solar cell manufacturers will have adopted our technology. We will add personnel here in Massachusetts at headquarters.

FIAP: What kind of people? Technical people, production people?

Craig: People assembling machines, people doing testing, people commissioning machines. We will need to hire process engineering people and good development people. On the wafer side, we are breaking ground on our new facility where we will build out demonstration capacity on the wafer manufacturing. The first piece of this expansion is in Massachusetts. We will hire people for process engineering and operations staff to work through that phase of the commercialization. Assuming everything looks good–and this is all about getting the validation and the data at this scale–we will quickly move to scale up at a much larger facility. The DOE loan gives us a chance to finance the scale up of our operation somewhere in the US.

FIAP: Do you view the loan's requirement that you scale up in the US as restrictive? Are your customers in the US or overseas?

Craig: A lot of the world's silicon comes from the US and gets shipped overseas. Shipping costs for anything other than modules which are very heavy because of glass, are pretty low–fractions of a percent of total value. So there is a clear opportunity to export something like that. I have a hard time calling it restrictive because it is a loan that is conditional, we haven't taken it yet, and we are free to do what we want. It's a fantastic option to allow us to scale here. That being said, the loan itself–if you take it–has tight restrictions on your freedom to operate. They're giving you a lot of money so that is expected.

FIAP: Are the restrictions related to the number of jobs in the US, or certain payroll in the US? Can you split it up?

Craig: The funding itself has to go for building a US plant. That's take it or leave it. It makes sense: the US taxpayer wants to see a plant here. If after that we want to do subsequent expansions we have to do that within the confines of the loan.

FIAP: And usually once you have a plant, making a new one far away is a really big decision.

Craig: It's a huge decision. The nice thing about our process, though, is that when you look at the key motivating factors to moving overseas that many people pursue–labor efficiency, power cost (which the US does very well on)–the US is very competitive. Labor efficiency and the ability to source materials locally are strong advantages in the US. The corporate tax rate doesn't help, and hopefully something will be done about that. The jobs we are creating are the elusive green jobs that we should be able to compete for.

FIAP: Would you talk a little about the make up of 1366's employees?

Craig: We are still heavy on the expensive brains. Out of a company of 40, all but 10 have at least a master's degree, and about 10-15 people have PhDs. We have about 3 mechanical engineers for every chemical engineer.

FIAP: As you scale up you'll have a lot more bachelors and 2-year degrees?

Craig: Exactly. As we grow the mix of the company will change dramatically. We are always going to keep hiring and trying to maintain a world class R&D group, but the bulk of the jobs will be different as we move into operations.

FIAP: R&D has a lot of different meanings. What is your meaning?
Craig: Most of what we do you would not classify as basic research. The masking technology is a good example. Our stated goal was to create a surface topography on a polycrystalline silicon wafer. There are several areas of development on that. One was the type of masking material that will work in the 5 or 10 ways it has to work. It has to stick, it has to create a system for coating the wafer at low cost, it has to temporarily resist the acid we use in our wet chemical etch. A lot of chemistry work has been done studying the interplay between the masking material and the etchant. Then we had to come up with the process and machines that can use the chemistry we developed. Our process equipment drew on what was used in other industries, but it is noticeably different from anything else in the world.

FIAP: 1366 grew out of Prof. Sachs' research work. If you look at the conceptual side of your processes, like forming silicon or new masking technologies, was the concept work something that came out of his group or had the concepts been around for a while requiring development?
Craig: A little of both. There is a lot of drawing on analogous processes in other industries, but there is a heavy amount of innovation and adaptation. On the wafer side, there were a few key inventions that had never been applied to silicon before.

FIAP: How have the problems that 1366 has had to address changed over the lifetime of the company?
Craig: From a macro perspective, the whole industry has had a massive pricing decline and a shift in manufacturing to China. These are things that we have to contend with. That's the main change. On the more positive side, there are more people today who think silicon is going to win because of how quickly the supply chain adapted and how much costs have declined. You don't hear as many people talking about the unstoppable rise of thin films that you heard two or three years ago. It hasn't altered much of what we have been doing.

FIAP: What new problems do you think 1366 will encounter as it ramps up production?
Craig: We're trying to limit some of the scaling issues. We are mitigating it by making commercial quality wafers today. As we scale, we don't have to increase the size of the machine or its rate significantly. We have a modular design. We will incrementally improve rates, but scaling will not involve having to dramatically improve them. Scaling will involve making sure that each piece of equipment behaves identically.

FIAP: How much interaction do you have with basic research labs?
Craig: We still have relationships with MIT, and that will hopefully always continue. We recruit a lot of people from there. We do projects with existing faculty members.

FIAP: What kind of projects do you do with faculty?
Craig: Things like characterization of wafers, for instance. Things where we can leverage their ability to characterize the nature of a problem but not necessarily solve it. If they start getting into the solving of problems you have issues of who owns what IP. But as part of the founding of this company MIT became a significant shareholder of 1366, and the original agreement contains an exclusive license agreement that includes subsequent innovations in certain areas. You could argue that they're the most sophisticated university in the world at doing this.

FIAP: Have you worked with other universities or national labs?
Craig: No other universities. We have received a handful of R&D grants from NREL and the Department of Energy.

FIAP: Can you talk about the types of problems these collaborations helped you solve? Did MIT publish any of their results?
Craig: We haven't yet.

FIAP: Since most academics want to publish, what was the incentive for MIT to do this work?
Craig: Some of it is work for hire. When Prof. Sachs was still at MIT, as part of the original license agreement some work was still allowed to be done by MIT. They were willing to continue development of the technology they licensed to 1366 and then we had exclusive license to the improvements. I should mention that Prof. Sachs made the very difficult decision to leave MIT last September. The reason he decided at the time was because he believed that we are at the cusp of doing something great at the company, and that this was a challenge he wanted to explore at this point in his life. It's not an easy decision to leave a tenured position surrounded by brilliant students and faculty. It's a huge boon for the company, and he's very happy about the choice he made.

FIAP: Are there any problems that MIT or the national labs have not been able to help you with?
Craig: Not that I can think of. I should say that we discuss this internally a lot. The core of what we are doing here is not inventing a new product. In semiconductor there's a clear delineation between design and process. In solar, the innovation is tied up in the process and machine. So it's harder to separate out the intellectual property.

FIAP: Can you talk a little about the advantages and disadvantages of receiving government funding versus private financing?
Craig: Government funding does not dilute our shareholders, though it tends to have more structure to it and more granular oversight. Private funding lets us pivot more quickly if the technology changes. We have been very happy with the grants we have received and we will continue to apply for grants.

FIAP: As you scale up, can you talk a bit about any concerns you have about the skill sets of academically oriented engineers versus operations oriented engineers.
Craig: In the last year we have tried to bring in more people with operations and strong commercial experience. That creates a bit of a mix and that will create some tension in some areas. It is constantly something we think about and try to evaluate. We just hired a Chief Operating Officer who has significant experience building fabs and setting up supply chains. He's going to look at things very differently from people who have spent more time tinkering in a lab.

FIAP: Thank you for taking the time to speak with us.

Update from the Committee on Careers and Professional Development

One of the greatest challenges physicists often face is to provide a broad and accurate picture of the many career paths available to students pursuing a degree in physics. For students majoring in physics, the most common (and in some cases only) professional physicist role models they encounter are their own professors or academic research advisors. Yet there exists a sizable amount of data that suggest an academic career is not the typical career path of the majority of physics graduates. At the same time, many well-intentioned mentors of physics students are often not well equipped to educate their students about non-academic physics career possibilities, or even to point them to resources that would help give them a competitive edge in the job market outside of academia.

According to a report by the AIP Statistical Research Center (SRC), physics departments in the United States currently graduate approximately 1,400 PhDs per year.[1] A significant proportion of these (~50%) do postdoctoral work, and most have the intention of eventually obtaining an academic faculty research position.[2,3] The AIP report on trends in the faculty job market indicates, however, that the total number of U. S. faculty has remained more or less the same since 2003.[3] According to this report, "While there were about 350 departures by tenured and tenure-track faculty during the 2006-2007 academic year…there were 475 recruitments for the same time frame, with 342 tenured and tenure-track faculty members hired in 2007-2008; this… is consistent with what we have seen in prior years.[3]"

So, while thousands of physics PhDs continue to pour out of our universities each year, many of them anticipating an academic career in physics, the majority of them will not ultimately follow that career path.

What about the non-academic career path options? The scientific research experience and expertise gained by earning a PhD in physics is precisely the preparation needed for non-academic research and development work conducted in industrial and national laboratory settings. Indeed, physicists with this level of training are in high demand in science and technology industries: the SRC report states that over one-third of graduating physics PhDs go directly from graduate school into a career path in the private sector. The remaining one-sixth of physics PhD graduates go either into other temporary positions besides postdocs or become unemployed. Data from the NSF Survey of Doctoral Recipients, moreover, indicate that the private sector has in fact been the largest permanent employment base (over 40%) for physics PhDs since 1971. So in order to present a complete physics employment and career path picture to graduating physics bachelors, masters, and PhDs, we in the physics community must expand the career and professional development focus for students to include significant private sector, industrial, and other non-academic components.

The APS Committee on Careers and Professional Development (CCPD) recognizes this need to more effectively disseminate information on the broad spectrum of career paths in physics to the APS membership, and it has benefitted greatly by several industrial physics members serving on the committee in recent years. Some of the CCPD's most recent projects include special physics career workshops at annual meetings, career panels and networking receptions, and special undergraduate events, all designed to inform and inspire students about the broad range of career paths pursued by physics degree recipients. CCPD has also worked with the APS Forum on Industrial and Applied Physics (FIAP) to host a Physics Careers in Industry and Government Workshop at last year's APS March Meeting, and continues to host an on-site Job Expo at the March Meeting to help bring together employers in science and technology fields with qualified physics graduates.

In addition, in 2011 the CCPD redesigned and added significant content to the APS Careers website that included an updated Professional Development Guide, resources for mentors and educators (e.g., physics employment statistics), physicist profiles, and information on the cost effectiveness of a physics degree.

Another program recently undertaken by APS is a series of free webinars designed to provide information to students, postdocs, and working physicists on physics careers and professional development. Past APS Webinars include "Physics Careers in Small Companies," with CCPD member Peter Stoltz of Tech-X Corp., "Making a Difference With Your Physics Degree," about physics entrepreneurship and venture philanthropy with fiber optics entrepreneur Frank Levinson, "Career Alternative for Physicists: Patent Law," with Hay Yeung Cheung of Myers Wollin LLC, and many other physics and physics career path topics. To find out more–and to view the archived recordings of previous webinars and presentations–please visit the APS Careers website (http://www.aps.org/careers/guidance/webinars/index.cfm).

CCPD's webinar broadcasts are very popular among students–especially when the topics have focused on career paths outside academia. The quality and diversity resources CCPD is able to offer ultimately depend on the background and expertise of the physicists we feature. CCPD therefore encourage APS units, such as FIAP, to become more involved with CCPD programs by, for example, volunteering to be featured in physicist career profile (http://www.aps.org/careers/physicists/profiles/index.cfm) or in the Physics InSight slideshow–a bi-monthly power point publication that physics departments display on LCD screens in common areas (http://www.aps.org/careers/insight/index.cfm). CCPD also welcomes FIAP members to participate in an APS Webinar broadcast directed toward undergraduate, graduate, postdocs, and early-career physicists to let them know about the many satisfying physics career paths available to them in industrial and other non-academic settings. For more information on these resources–or to get involved in bringing your story to the physics community–please contact Crystal Bailey at bailey@aps.org.

Crystal Bailey is the Education and Careers Program Manager at the APS.

1. Focus on Physics Graduate Degrees, AIP Statistical Research Center (July 2011)
2. Focus on Physics Doctorates One Year Later, AIP Statistical Research Center (November 2010)
3. Focus on The Faculty Job Market in Physics and Astronomy Departments, AIP Statistical Research Center (June 2010)
4. Focus on Physics Doctorates Initial Employment, AIP Statistical Research Center (June 2011)

Election results

Councillor: Gregory Meisner

He received his B.A., M.S., and Ph.D. degrees in Physics from the University of California, San Diego, where is research focused on the superconductivity and magnetism of new ternary compounds. Following a post doc at Los Alamos National Lab, where he studied heavy fermion systems, he joined GM and has been conducting industrial research there for over 28 years. He has published over 90 refereed publications and has 10 patents.

Vice Chair: John Rumble

Dr. Rumble received a B.A. in Chemistry from Cornell University, a M.A. in Chemistry from the City University of New York, and a Ph.D. in Chemical Physics from Indiana University. For 36 years, Dr. John Rumble has been a leader in scientific and technical (S&T) data, including physics, materials, and engineering. For 24 years, he worked for the National Institute of Standards and Technology, serving as Director of the NIST Standard Reference Data Program and Chief of the NIST Measurement Services Division. He is now President of R&R Data Services, in Gaithersburg MD.

Dr. Rumble has written three books and many articles on S&T data. He has published papers on atomic and molecular physics.

Member-at-Large: Jason Cleveland

In 1990, he obtained a B.A. in Math and Physics from the University of Minnesota where he was a Goldwater scholar. Cleveland received his Ph.D. in Experimental Physics from UCSB in 1995. Jason Cleveland is currently CEO of Asylum Research, an atomic force microscope company he co-founded 12 years ago. He is an author on more than 40 scientific publications and a co-inventor on over 20 patents.

Member-at-Large: Cha-Mei Tang

Cha-Mei Tang received B.S. ('71), M.S. and E.E. ('71) and Sc.D. ('77) from the Electrical Engineering and Computer Science Department at MIT. She founded Creatv MicroTech in 1996 initially focusing on developing novel x-ray anti-scatter grids and nuclear collimators to improve image quality. In 2000, she led the company into the field of medical diagnostics developing sensitive detection instruments and assays, making products requiring combined experience of microfabrication, instrumentation and assay development. She received numerous awards, including Fellow of the American Physical Society in 1990 and the most outstanding woman scientist in the Federal Government by Women in Science and Engineering in 1992.

Call for nominations: FIAP members for APS Fellowship

The APS is now accepting nominations for the 2011 class of APS Fellows. The deadline for consideration by FIAP is June 1, 2011, and we encourage members to nominate outstanding candidates.

Instructions for preparing nominations are available at: http://www.aps.org/programs/honors/fellowships/nominations.cfm.

March Meeting preview: FIAP-Fest 2012

We have an exciting and packed agenda for you this year at the March Meeting of the APS in Boston, from February 27 to March 3. We have something for everyone, whether you are in academia, industry or government, a graduate student or retiree thinking of starting your own business. Let's begin with the Invited Symposia:

- Flexible and rolled-up semiconductor nanomembranes
- Advanced quantum materials for future information technology
- Advanced electromagnetic imaging and remote sensing: from DC to daylight
- Advanced characterization of transistor gate stacks and interfaces
- Robust energy storage with engineered Silicon
- Physics of color reflective displays
- High k dielectrics for high carrier mobility channel applications
- Magnetic materials and magnetism research for energy applications
- Astronomy's detectors and physics education
- Superconductivity and spin transport (McGroddy Prize, Adler Leacturship and Pake Prize)
- Quantum design of low-dimensional materials structures for enhanced solar energy conversion

Then, there are the Special Focus Sessions:

- Frontiers in computational thermodynamics and materials
- Scalable photovoltaic technologies
- Students, physics and education

And our FIAP-sponsored Expert Lunch program for students of all ages (first come, first serve):

- Applied physics, technology and industrial applications: a synergistic triad
- The pleasures, the excitement, the challenges and the dangers of an industrial career
- Best practices for defining, creating and attracting employment opportunities for physicists in industry

And that doesn't even take into account the networking opportunities and the chance to meet and greet your colleagues and friends. There are even opportunities to volunteer, as in handing out and collecting feedback questionnaires at the respective events described above. Come one, come all, plug in and become more active in your society–that's the FIAP way!

Mark Bernius, VC and FIAP Program Chair

Session A14 Focus Session: Spins in Semiconductors - Magnetic Semiconductors I
Sponsor: GMAG DMP FIAP
Chair: Paul Crowell, University of Minnesota Room: 212
Invited Speakers: Margaret Dobrowolska

Session A15 Focus Session: Spins in Metals - Thermal Effects on Magnons and Spin Currents
Sponsor: DMP FIAP GMAG
Chair: Stewart Barnes, University of Miami Room: 213
Invited Speakers: C.L. Chien

Session A17 Focus Session: Thermoelectrics - Nanostructured and Oxide TE
Sponsor: DMP GERA FIAP
Chair: Oded Rabin, University of Maryland Room: 252A
Invited Speakers: Mercouri Kanatzidis

Session A20 Invited Session: Advanced Quantum Materials for Future Information Technology
Sponsor: FIAP
Chair: Cherry Murray, Harvard University Room: 253C
Invited Speakers: Phaedon Avouris, Ali Yazdani, William Koehl, Pablo Jarillo-Herrero, Donhee Ham

Session A24 Materials: Synthesis, Growth and Processing (Bullk and Films)
Sponsor: FIAP
Chair: Dmitri Tenne, Boise State University Room: 256

Session B14 Focus Session: Spins in Semiconductors - Spin Relaxation in Semiconductors and Diamond
Sponsor: GMAG DMP FIAP
Chair: Aubrey Hanbicki, Naval Research Laboratory Room: 212
Invited Speakers: Xavier Marie

Session B15 Focus Session: Spins in Metals: Spin Torque Switching and Magnetic Anisotropy Control
Sponsor: DMP FIAP GMAG
Chair: Ilya Krivorotov, University of California, Irvine
Room: 213

Session B16 Hubbard Model
Sponsor: DCMP
Chair: Vladimir Dobrosavljevic, Florida State University
Room: 251

Session B17 Focus Session: Thermoelectrics - Nanowires and Other Nanostructures
Sponsor: DMP GERA FIAP
Chair: David Broido, Boston College
Room: 252A
Invited Speakers: Li Shi

Session B20 Invited Session: Astronomy's Detectors and Physics Education
Sponsor: FEd FIAP
Chair: James Beletic, Teledyne Imaging Sensors
Room: 253C
Invited Speakers: James Beletic, Vyshnavi Suntharalingam, George Ricker, Zoran Ninkov, John Kovac

Session B24 Electronic Structure: Theory and Spectra
Sponsor: FIAP
Chair: Jan Musfeldt, University of Tennessee
Room: 256

Session D15 Focus Session: Spins in Metals - Ultra Fast Dynamics
Sponsor: DMP FIAP GMAG
Chair: Shufeng Zhang, University of Arizona
Room: 213
Invited Speakers: Ilie Radu, Alexey Melnikov

Session D20 Invited Session: Advanced Electromagnetic Imaging and Remote Sensing: From DC to Daylight
Sponsor: FIAP
Chair: Peter Weichman, BAE Systems
Room: 253C
Invited Speakers: Eugene Lavely, Peter Weichman, Thomas Kragh, Dan Bliss, Eric Miller

Session D24 **Bionanotechnology and Nanostructured Sensors**
Sponsor: FIAP
Chair: Jayant Kumar, University of Massachusetts Lowell
Room: 256

Session H14 Focus Session: **Spins in Semiconductors - Electrical Spin Injection**
Sponsor: GMAG DMP FIAP
Chair: Jean Heremans, Virginia Tech
Room: 212
Invited Speakers: Connie H. Li

Session H15 Focus Session: **Spin and Dynamics in Metal, Spin logic and Spin-Based Devices**
Sponsor: DMP FIAP GMAG
Chair: Jimmy Zhu, Carnegie Mellon University
Room: 213
Invited Speakers: Jayasimha Atulasimha, Srikant Srinivasan

Session H17 Focus Session: **Thermoelectrics - Characterization/Molecular junctions/Magnetic and Low Temp**
Sponsor: DMP GERA FIAP
Chair: Jeffrey Urban, Lawrence Berkeley National Laboratory
Room: 252A
Invited Speakers: Pramod Reddy

Session H24: **Electrical and Thermal Properties of Semiconductors**
Sponsor: FIAP
Chair: Michael Manfra, Purdue University
Room: 256

Session H27 Invited Session: **McGroddy Prize, Adler Lectureship, and Pake Prize: Superconductivity and Spin Transport**
Sponsor: GMAG DMP FIAP
Chair: Paul Crowell, University of Minnesota-Minneapolis
Room: 258AB
Invited Speakers: P.C. Canfield, Robert Cava, Stuart Parkin, T. Venkatesan, Jian Shen

Session H33 Focus Session: **Scaleable Technologies for Photovoltaics**
Sponsor: GERA FIAP
Chair: Mark Bernius, Dow Chemcial Company
Room: 106
Invited Speakers: Gregory N. Nielson

Session J14 Focus Session: Spins in Semiconductors - Spin-Orbit Coupled Electrons and Holes in Semiconductors
Sponsor: GMAG DMP FIAP
Chair: Giovanni Vignale, University of Missouri
Room: 212
Invited Speakers: Alex Hamilton, Ulrich Zuelicke

Session J15 Focus Session: Spins in Metals - Spin Transport in Novel Devices and Structures
Sponsor: DMP FIAP GMAG
Chair: Peter Metaxas, University of Western Australia
Room: 213

Session J28 Focus Session: Frontiers in Computational Thermodynamics of Materials
Sponsor: FIAP DCOMP
Chair: Stefano Curtarolo, Duke University
Room: 258C
Invited Speakers: David Landau, Mark Asta

Session L14 Focus Session: Spins in Semiconductors - Magnetic Semiconductors II
Sponsor: GMAG DMP FIAP
Chair: George Kioseoglou, University of Crete
Room: 212
Invited Speakers: Tomas Jungwirth

Session L15 Focus Session: Spins in Metals - Resonance Phenomena I, Spin Wave Excitation and Spin Torque Oscillators
Sponsor: DMP FIAP GMAG
Chair: Andrew Kent, New York University
Room: 213
Invited Speakers: Marco Madami, Sergei Urazhdin

Session L17 Focus Session: Thermoelectrics - Electronic Structure and Transport
Sponsor: DMP GERA FIAP
Chair: Li Shi, University of Texas at Austin
Room: 252A
Invited Speakers: David Singh

Session L27 Invited Session: Quantum Design of Low-Dimensional Materials Structures for Enhanced Solar Energy Conversion
Sponsor: DCMP FIAP
Chair: Zhenyu Zhang, University of Science and Technology of China
Room: 258AB
Invited Speakers: Alex Zunger, Efstratios Manousakis, Vladimir Bulovic, Zhenchao Dong, Marlan Scully

Session L28: **Electricity-to-Light Conversion: Solid State Lighting**
Sponsor: FIAP GERA DMP
Chair: Theodore Moustakas, Boston University
Room: 258C

Session M28: **FIAP Business Meeting**
Sponsor: FIAP
Room: 258C

Session P14 Focus Session: **Spins in Semiconductors - Quantum Dots and Qubits**
Sponsor: GMAG DMP FIAP
Chair: Connie Li, Naval Research Laboratory
Room: 212
Invited Speakers: Rafal Oszwaldowski, Lieven Vandersypen

Session P15 Focus Session: **Spins in Metals - Spin Current Generation and Spin Motive Force**
Sponsor: DMP FIAP GMAG
Chair: Chia-Ling Chien, Johns Hopkins University
Room: 213
Invited Speakers: Yasuhiro Fukuma

Session P17 Focus Session: **Thermoelectrics - TE and Thermal Conductivity**
Sponsor: DMP GERA FIAP
Chair: David Singh, Oak Ridge National Laboratory
Room: 252A

Session P24: **Fractional Quantum Hall Effect I**
Sponsor: FIAP
Chair: Michael Manfra, Purdue University
Room: 256

Session P28: **Optical Applications: Nonlinear Optics, Waveguides, and Novel Structures**
Sponsor: FIAP
Chair: Doug Natelson, Rice University
Room: 258C

Session Q14 Focus Session: **Spins in Semiconductors - Spin Dependent Transport**
Sponsor: GMAG DMP FIAP
Chair: Robert Lillianfeld, Purdue University
Room: 212
Invited Speakers: Joerg Wunderlich

Session Q20 Invited Session: **Robust Energy Storage with Engineered Si**
Sponsor: FIAP
Chair: Susan Babinec, A123 Systems
Room: 253C
Invited Speakers: Candace Chan, Jason Goldman, Claus Daniel, Mark Obrovac, Baris Key

Session Q24: **Fractional Quantum Hall Effect II**
Sponsor: FIAP
Chair: Michael Mulligan, Massachusetts Institute of Technology
Room: 256

Session Q28: **Applications of Semiconductors, Dielectrics, Complex Oxides**
Sponsor: FIAP
Chair: Ernesto Marinero, Hitachi Global
Room: 258C

Session Q37 Focus Session: **Students, Physics and Innovation**
Sponsor: FIAP FEd
Chair: Randy Tagg, University of Colorado Denver
Room: 108
Invited Speakers: Douglas Arion

Session T14 Focus Session: **Spins in Semiconductors - Spins and Edge States**
Sponsor: GMAG DMP FIAP
Chair: Yuli Lyanda-Geller, Purdue University
Room: 212
Invited Speakers: Biswajit Karmakar

Session T20 Invited Session: **Advanced Characterization of Transistor Gate Stacks and Interfaces**
Sponsor: FIAP
Chair: Chris Van Der Walle, University of California, Santa Barbara
Room: 253C
Invited Speakers: Matthew Copel, Jon Pelz, Justin R. Weber, Paul McIntyre, Gennadi Bersuker

Session T24: **Fractional Quantum Hall Effect III**
Sponsor: FIAP
Chair: Rui-Rui Du, Rice University
Room: 256

Session T28: **Semiconductors**
Sponsor: FIAP
Chair: Loren Pfeiffer, Princeton University
Room: 258C

Session V20 Invited Session: **High k Dielectrics for High Carrier Mobility Channel Applications**
Sponsor: FIAP
Chair: Jueinai Kwo, National Tsing Hua University
Room: 253C
Invited Speakers: Peide Ye, Minghwei Hong, John Robertson, Marc Heyns

Session V24: **Low-Dimensional Semiconductors**
Sponsor: FIAP
Chair: Enrico Bellotti, Boston University
Room: 256

Session V27 Invited Session: **Flexible and Rolled Up Semiconductor Nanomembranes**
Sponsor: DCMP FIAP
Chair: Pablo Bianucci, Ecole Polytechnique de Montreal
Room: 258AB
Invited Speakers: Max G. Lagally, Feng Liu, Oliver Schmidt, Xiuling Li, Weidong Zhou

Session W14 Focus Session: **Spins in Semiconductors - Ferromagnetism and Spin Dynamics in Semiconductors**
Sponsor: GMAG DMP FIAP
Chair: John Peters, Northwestern University
Room: 212

Session W15 Focus Session: **Spins in Metals - Domain Wall, Vortex, Magnonic Based Devices**
Sponsor: DMP FIAP GMAG
Chair: Peter Fischer, Lawrence Berkeley National Laboratory
Room: 213

Session W17: **Optics of Semiconductor Nanowires**
Sponsor: FIAP
Chair: Steve Erwin, Naval Research Laboratory
Room: 252A

Session W24: **Integer Quantum Hall Effect**
Sponsor: FIAP
Chair: Michael Zudov, University of Minnesota
Room: 256

Session X14 Focus Session: **Spins in Semiconductors - Spin-Orbit Interaction and Relaxation in Si and Ge**
Sponsor: GMAG DMP FIAP
Chair: Nicholas Harmon, University of Iowa
Room: 212
Invited Speakers: Pengke Li

Session X15 Focus Session: Sp**in and Dynamics in Metal, Resonance Phenomena II: FMR in Magnetic Nanostructures**
Sponsor: DMP FIAP GMAG
Chair: Xin Fan, University of Delaware
Room: 213
Invited Speakers: Luqiao Liu

Session X20 Invited Session: Physics of Color Reflective Displays
Sponsor: FIAP
Chair: Gary Gibson, Hewlett Packard - Palo Alto
Room: 253C
Invited Speakers: Jason Heikenfeld, Gary Gibson, Andre Arsenault, Asad Khan, Brian Gally

Session Y2 Invited Session: Magnetic Materials and Magnetism Research for Energy Applications
Sponsor: GMAG FIAP
Chair: Elke Arenholz, Lawrence Berkeley National Laboratory
Room: 204AB
Invited Speakers: Oliver Gutfleisch,Hideo Ohno, Vitalij Pecharsky, George Hadjipanayis, Matthew Willard

Session Y15 Focus Session: Spins in Metals: Spin Torque Theory, Spin Dependent Transport
Sponsor: DMP FIAP GMAG
Chair: Markus Eisenbach, Oak Ridge National Laboratory
Room: 213
Invited Speakers: Yong Wang

APS Fellowship

The Forum on Industrial and Applied Physics is proud to present a list of members nominated by FIAP and elected to Fellowship in the American Physical Society. Each new fellow is elected after careful and competitive review and recommendation by the FIAP Fellowship Committee, additional review by the APS Fellowship Committee and final approval by the full APS Council.

Deadline for APS Fellowship Nomination: Friday, June 1, 2012

APS Fellows Nominated by FIAP

Atkinson, William [2011]
Boeing Company
Citation: For academic contributions in the areas of nuclear physics and for substantial applications of radiation technology to spaceborne applications in the aerospace community.

Boykin, Timothy [2011]
University of Alabama, Huntsville
Citation: For contributions to the theory and full-bandstructure modeling of semiconductor nanostructures.

Brown, April [2011]
Duke University
Citation: For outstanding contributions to development and application of molecular beam epitaxy to the formation advanced device structures, with particular contributions to the advancement of the strained heterostructures forming modern microwave devices.

Cleveland, Jason [2011]
Asylum Research
Citation: For remarkable and lasting contributions to the field of scanning probe microscopy, both academic and commercial.

Ginley, David [2011]
National Renewable Energy Laboratory
Citation: For sustained scientific contributions in the broad area of solar energy conversion devices and services to the physics community, including chairing and organizing a series of focus sessions on energy related topics and giving invited talks and active participation in outreach to young physicists.

Hayes, Robert [2011]
Washington TRU Solutions, LLC
Citation: For furthering the use of nuclear technology in the areas of radiation safety, nuclear engineering and nuclear waste disposal through the use of physical science.

Hong, Minghwei [2011]
National Taiwan University
Citation: For pioneering in III-V semiconductor metal oxide semiconductor field effect transistors including the landmark discovery of high dielectric constant oxide films on GaAs surface with low interface states and unpinned Fermi level, and the first demonstration of inversion-channel GaAs MOSFET, timely for science and technology beyond Si CMOS.

Huang, Danhong [2011]
Air Force Research Lab - Kirtland
Citation: Significant contributions to our understanding of optical absorption and electron transport properties of quantum devices.

Kaviany, Massoud [2011]
University of Michigan, Ann Arbor
Citation: For seminal contributions to the understanding of phonon physics and thermal transport in fluids and solids; and for pioneering developments in the semiclassical simulation of electronic and phonon transport.

Khurgin, Jacob [2011]
Johns Hopkins University
Citation: For diverse contributions to understanding the underlying physics and improving the performance of numerous electronic and optical devices, such as semiconductor second-order nonlinear optical generators, intersubband semiconductor lasers and Raman oscillators, slow light, and plasmonic devices.

Klimeck, Gerhard [2011]
Purdue University
Citation: For the development, application, and dissemination of atomistic, quantum simulation tools for nanoelectronic devices.

Meinhart, Carl [2011]
University of California, Santa Barbara
Citation: For contributions to the seminal developments of micron resolution particle image velocimetry and free-surface microfluidics for surface enhanced Raman scattering technology, and for providing deeper understanding of the flow of fluids over surfaces in the extremes of microscopic slip and high Reynolds number turbulence.

Mitin, Vladimir [2011]
SUNY, Buffalo
Citation: For contributions to phonon enhancement of sensors and detectors and to controlled carrier kinetics in sensors with high responsivity.

Narayanan, Vijay [2011]
IBM T.J. Watson Research Center
Citation: For seminal contributions to the science and technology of high dielectric constant oxide materials and metal gate based transistors that have redefined silicon microelectronics.

Schiff, Eric [2011]
Syracuse University
Citation: For pioneering applied physics research on thin film silicon photovoltaic materials and devices.

Schuber, Mathias [2011]
University of Nebraska, Lincoln
Citation: For the development of generalized ellipsometry and the invention of the Optical Hall Effect, and their transformative potential for industrial characterization of materials properties, for example in liquid crystal displays and semiconductor device structures.

Stalder, Kenneth [2011]
Stalder Tech & Reserch
Citation: In recognition of his application of atomic, molecular and plasma physics in the industrial and commercial sector and of his pioneering work in the area of plasmas created in liquids.

Tritt, Terry [2011]
Clemson University
Citation: For his career-long contributions to the science and engineering of thermoelectric materials, the industrial application of that knowledge, and for the education and promotion of numerous young scientists and engineers.

Weller, Robert [2011]
Vanderbilt University
Citation: For contributions to the understanding of the interactions of radiation with microelectronic materials and devices.

Willander, Magnus [2011]
Linkoping University, Norrkoping
Citation: Pioneering work on realization of polymer and silicon-germanium transistors and silicon carbide. Significant contributions on modeling solid and soft nanostructures, and experimental works on nanostructures, particularly zinc oxide nanostructures.

2012 Prize and Award Recipients

2012 George E. Pake Prize Recipient

Thirumalai Venkatesan
National University of Singapore

Citation: "For his exemplary scientific career in research, industrial leadership, and guidance of new generations of physicists in the creation new ventures by innovation."

Background:

Prof. Venkatesan spent 17 years with Bell Labs and Bellcore in various capacities before becoming a Professor of ECE and Physics at the Superconductivity Center at University of Maryland for the next 17 years. In between he was the founding director of the surface modification Labs at Rutgers University and over the last 4 years he has established a multi disciplinary Nano Institute at the National University of Singapore where he is the Director. He is the inventor of the pulsed laser deposition process and has published over 500 papers in the field of oxide films and hetero structures and has been a pioneer in the field of Oxide Electronics. He is among the top 100 most cited Physicists (global rank of 66) with a Hirsch index of ~ 80. He founded Neocera in 1989 and this company is globally recognized for PLD systems and magnetic field imaging magma systems. His students/ researchers (about 10 of them) have founded close to 15 different companies. He is a Fellow of the American Physical Society, Fellow of the World Innovations Forum, and winner of the Bellcore Award of excellence and has been a member of the Physics Policy Committee in Washington DC. He got his PhD from The City University of New York in 1977 and his MS and BS degrees from the Indian Institute of Technology at Kanpur and Kharagpur respectively. His current field of interest is electronic and magnetic properties of nano structured oxide films and interfaces.

2012 Ken Hass Outstanding Student Paper Award

Jose R. Sánchez-Pérez
University of Wisconsin Madison

Direct-bandgap infrared light emission from tensilely strained germanium nanomembranes

Session Q28, 11:15 AM–2:15 PM, Wednesday, February 29, 2012

Abstract

Silicon, germanium, and related alloys, which provide the leading materials platform of electronics, are extremely inefficient light emitters because of their indirect fundamental energy bandgap. This basic materials property has so far hindered the development of group-IV photonic active devices, including diode lasers, thereby significantly limiting our ability to integrate electronic and photonic functionalities at the chip level. We show that Ge nanomembranes can be used to overcome this materials limitation. Theoretical studies have predicted that tensile strain in Ge lowers the direct energy bandgap relative to the indirect one. We demonstrate [1] that mechanically stressed nanomembranes allow for the introduction of sufficient biaxial tensile strain to transform Ge into a direct-bandgap, efficient light-emitting material that can support population inversion and therefore provide optical gain.

Collaborators

CICEK BOZTUG, Boston University, FENG CHEN, University of Wisconsin Madison, FAISAL SUDRAD JAT, Boston University, DEBORAH PASKIEWICZ, R.B. JACOBSON, University of Wisconsin Madison, ROBERTO PAIELLA, Boston University, MAX LAGALLY, University of Wisconsin Madison