# Travel Grants to Foster International Collaborations

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***Abstract*** *— The successful achievement of goals and objectives in science and engineering research projects requires a broad and diverse perspective to propose and implement solutions. Many project solutions thus require a "team" approach with the appropriate technical knowledge coming from a variety of disciplines. Collaboration between scientists and engineers has become a conventional way to attack complex problems. This collaboration often time s extends beyond national borders ; the important potential outcomes of globalization drive an interest in increasing international collaborations. An opportunity for women scientists and engineers to initiate international collaborations is described in t his paper. A travel grant award, the Women's International Science Collaboration (WISC), provides funding for international travel to initiate research collaborations and to write a grant proposal with a foreign scientist. The award is administered by the American Association for the Advancement of Science (AAAS) and supported by the National Science Foundation (NSF). The paper describes the experience of an awardee, a female faculty member in Electrical Engineering at the University of Arkansas. The in ternational collaborator is an Engineering faculty member affiliated with the University of Edinburgh through the Scottish Microelectronics Centre (SMC) in Scotland and the collaborators' common research interest is in the area of silicon through -wafer int erconnects, an enabling technology for three -dimensional (3 -D) packaging of microelectronic devices. The grant application process will be described including the choosing of an international collaborator, a specific collaborative research project, and po tential funding agencies. Next, the international collaboration experience in terms of specific outcomes is described, including the unique involvement of a U.S. graduate student doing research in this specific technical area. The benefits gained from th is experience will be discussed.*

***Index Terms*** *— International collaborations, Travel grant, Inter national opportunities, Through -silicon via technology .*

## I. INTRODUCTION

An important approach to solving technical problems in science and engineering fields is to combine the expertise of multiple investigators for the proposed solution. It is nearly impossible to find technical problems today that do not require a multidisciplinary approach, especially for complex sophisticated problems. The combining of perspectives and technical expertise has become a very positive approach for problem solving and seems only to be increasing in popularity. Problem solutions typically formed in this manner are complete and thorough. Exchanging ideas and data in an international collaboration has resulted in successful cooperative activities for institutions with complementary research strengths [1]. International exchange programs for faculty supervised student teams have also provided opportunities for students to experience technical, cultural, and social aspects of a different country [2]. Another approach to creating an international experience that involves a minimum time away from a student's home institution but provides an opportunity to experience another culture is given by the Virtual Design Studio project co-developed by Union College and the Middle East Technical University in Turkey [3]. Collaborating within a discipline or across disciplines has clearly been a successful way to approach problems. It would be unusual today to write a proposal for research funding that does not include multiple investigators and involve multiple disciplines. While this approach is conventionally used, the collaboration many times will involve investigators from the same country. Same country collaboration is typically easier to coordinate due to the ease in travel for investigative meetings. Also many funding agencies are government based so they will tend to encourage and support research activities for collaborators within their country. Unfortunately, international collaboration is becoming harder to initiate and establish but not impossible with programs such as the one described in this paper. The need for international collaboration is clear and establishing this type of activity is promoted in academic institutions, research institutes, and industry. The pathway to creating and sustaining these collaborations is not always easy to establish.

## II. TRAVEL GRANT PROGRAMS

An existing program for fostering international research ties is the Women's International Science Collaboration (WISC). This program was initiated in 2001 and has had six rounds of competition. Approximately two hundred travel grants have been awarded in this program to date. The program provides funding for international travel to initiate research collaborations and to write a grant proposal with a foreign scientist. The award is administered by the AAAS and supported by the National Science Foundation (NSF) [4]. Eligible scientists/engineers are men and women with a Ph.D. that are U.S. citizens or permanent residents or graduate students that are Ph.D. candidates. Male co-PI applications must be accompanied by an application from a female co-PI as part of a U.S. research team. The outcome of this grant program is a research proposal to be submitted to any other appropriate funding agency. This program is designed to create new collaborations with scientists and engineers in Central/Eastern and Western Europe, the Newly Independent States of the former Soviet Union, Near East, Middle East, Africa, the Americas, Pacific, and Asia. The grant amount varies between a maximum of $4000 or $5000 depending on the region requested. The U.S. scientist can spend up to four weeks in the partner country.

Many other grant programs are available for establishing international collaborations. The NSF has specific programs to encourage U.S. researchers to enhance their programs through international cooperation [5]. They support international research and education through fellowships, travel grants, summer institutes, supplements to existing grants, and workshops. Support is available for graduate students also via the Doctoral Dissertation Enhancement program and the International Research Experiences for Students program. Another grant program administered by The National Academies is called the Twinning Program with funding provided by NSF. This program supports scientific collaboration with Bulgaria, Estonia, Latvia, Lithuania, Poland, and Slovakia. The goal of the twinning program is to foster the development of *new* international research partnerships. Eligibility is limited to U.S. researchers who have received a Ph.D. within the past ten years. The partners, once established, are encouraged to apply to NSF for longer term support. Another program to mention, the International Foundation for Science (IFS), provides support to researchers *from* developing countries. Research grants as well as travel grants are available in that program.

These programs, like many, are a response to a need for international collaboration, a hope of acquiring a diverse perspective, and a desire to promote international partnerships for young researchers. Many people have invested much time and effort towards developing recruiting and retention programs that provide diversity and help to maintain a global competitiveness. The Global Alliance in Science and Engineering for Diversifying the Workforce was created to provide opportunities to share information in education, industry, government and professional associations from different countries [6]. It involved a collaborative initiative of the AAAS, Women in Engineering Programs & Advocates Network (WEPAN), and the Association for Women in Science (AWIS). While one focus of this organization is to increase the role and participation of women in the science/engineering fields, the overall goal is to support all efforts to diversify the global technical workforce. This purpose of this alliance is to create a structure for collaboration among various institutions worldwide. Alliances such as these give a framework to the many opportunities that exist for international cooperation.

### CHOOSING A COLLABORATOR

Clearly many unique collaborative teams have been formed and successful projects accomplished by collaborators from different countries. Although it is not always clear how to form teams of this nature, there are many different routes existing for this type of activity. Reading the literature to find a research group that complements your technical interest is one way. Attending international conferences is probably one of the best ways to find research contacts and initiate collaborative discussions. Upon receiving the WISC travel grant solicitation, the PI contacted a previous conference attendee, Professor Walton, from the 2001 MEMS Packaging Conference held in Edinburgh, UK. Professor Walton offered a laboratory tour of the Scottish Microelectronics Centre (SMC) near the end of the conference and the PI was involved in this tour. SMC is located on the University of Edinburgh campus and has strong industrial links. It is a unique combination of offices, cleanroom, and analytical laboratories with some space leased to incubation companies. This laboratory is very impressive and offers a combination of research and education in the microelectronics/microsystems area. The ability to work in that setting with a group that had similar research interests was very attractive.

## III. TECHNICAL AREA FOR COLLABORATION

The area chosen for collaborative exploration was vertical interconnects. This was due to the common research interests between each group and a focus for the UA group in a DARPA funded program to investigate fabrication of through-silicon vias, essentially the ability to etch through silicon to form an electrical interconnect. Future microelectronic devices will require the integration of semiconductor processes to form vertical interconnects with the fabrication of electronic devices while maintaining device functionality. The processing techniques under investigation at UA include: deep silicon etching to form small diameter vias, insulator lining, adhesion/barrier layer deposition, copper seed layer deposition, copper

electroplating, silicon wafer thinning, insulator deposition on the wafer backside, and contact metallization. It was natural to work with SMC on process integration issues associated with foundry-processed silicon wafers, one of their technical strengths. The SMC has been one of the pioneers associated with the development of post processing foundry wafers. This initially started in the early 90's with the development of liquid crystal on silicon microdisplays.

## IV. INTERNATIONAL COLLABORATION EXPERIENCE

The remainder of this paper will describe the experiences of the WISC travel grant awardee, the doctoral student, and foreign sponsor. The awardee, or PI, is a female faculty member in the Electrical Engineering Department at the University of Arkansas (UA). Her research interests are in the general area of microelectronics. The foreign sponsor for the PI is a Professor in the School of Engineering and Electronics at the University of Edinburgh. The graduate student is a doctoral candidate in the Microelectronics-Photonics program at the UA, a multi-disciplinary graduate program involving both the College of Engineering and the College of Arts and Sciences. She is also a NSF IGERT Fellow and heavily involved in the research project of interest to both institutions.

### PI EXPERIENCE

From the initial contact with Professor Walton, I was encouraged to find an interested collaborator who was very willing to provide assistance with the application process. He replied promptly to all of my requests and offered many suggestions and help in getting ready for the trip once the grant was awarded. After the award was announced, it was important to communicate expectations and objectives for the trip. Our lists are similar and they are shown in Table I. While brief, the lists target the objectives for the visit. All of the objectives were met during the two week visit except drafting a research plan; that objective is a current task for the PI and foreign sponsor.

| UA | SMC |
|---|---|
| Share the through-silicon via (TSV) process | Understand the TSV technology and technical issues |
| Describe integration and bonding issues | Evaluate equipment needs |
| Describe UA facilities and look for overlap in capabilities between UA/SMC | Introduce US visitors to appropriate people to enhance potential collaboration |
| Talk about specific common research interests | Discuss opportunities for student interchange |
| Discuss potential funding agencies and requirements | Investigate opportunities to procure funding |
| Draft a research plan | Discuss SMC's contribution to a collaboration |
| Discuss a possible student exchange program | Discuss technology transfer and the challenges |

TABLE I. List of Visit Objectives for each Investigator.

Upon arriving in Edinburgh, a day was spent in orientation and introduction to the campus. On the second day I presented an overview and then a seminar was given by the UA graduate student, Silke Spiesshoefer. Silke has been involved in this technology for the past few years while pursuing her doctoral degree in the Microelectronics-Photonics program. The seminar served as a forum for us to share the TSV fabrication process technology to the SMC researchers so that a joint project could be defined. We also shared potential project ideas after the seminar to stimulate the future discussions that would be held. After the seminar a tour of the SMC cleanroom was held. Their cleanroom has a unique design with individual clean bays and a dedicated chase area for utilities. Each bay has equipment typically related in terms of processing capability and some bays are leased to companies. This tour showed all materials processing capabilities as well as a laboratory for sample imaging, sample preparation, and analytical studies.

At the end of the first week, a joint workshop session was held with a group of interested SMC researchers. Several project topics were discussed in a brainstorming fashion. Projects fell into two groups – 1) applications for TSV technology 2) process development/optimization. Many applications were discussed such as ones that involve stacking of integrated circuits. In this case, the ability to connect *through* silicon will allow many different types of electronic devices that are integrated into one system. The microelectromechanical systems (MEMS) area that relies heavily on deep silicon etching was also discussed. In terms of process development and optimization, a project involving chemical mechanical planarization (CMP) would be ideal because this is a process not currently available at UA. This procedure could be used to expose vias by gently polishing after the wafer thinning steps (mechanical grinding and chemical spin spray). Currently we use a blanket dry etch to expose the vias from the back side and it has some problems related to process uniformity yielding poor wafer planarity. CMP is available at SMC and serves as a complementary capability to our process flow.

The remainder of the visit was spent on considering the potential projects and key points for proceeding with the collaboration. Funding sources were also discussed. NSF seems to be the most appropriate agency to pursue funding for the

type of projects discussed. Many opportunities exist in the NSF international program, however they appear to be separated by the type of budget requirement. For example, there are programs for student fellowships, postdoctoral fellowships, or international travel with extended stays for research. It is difficult to get a stipend, travel, and materials/supplies funded through a single proposal. Regardless of the constraints, a proposal will be submitted in the fall 2004 to the International program at NSF. This visit was a tremendous learning experience and I hope to be able to make a return visit due to a funded project and give a student the opportunity to work on a research project at the University of Edinburgh.

### GRADUATE STUDENT EXPERIENCE

Two years ago, I spent six weeks at the Fraunhofer Institute for Microelectronics in Munich, Germany working on a research project involving 3D integration. This internship was the first international experience in my technical career. I not only learned about the cultural differences between work environments but also how important it is to have international collaborations. They not only allow for technical enhancement but also allow us to see how others seek out solutions, which in turn permits us to see things from different points of view in hopes to become better problem solvers. My visit to the SMC at the University of Edinburgh allowed me to take the international experience to a new level, a level in which I could share my knowledge on a topic that with joint efforts could be incorporated into a technological application. I was given the opportunity to present my work on 3D integration during a seminar at the SMC. This was well received and discussions took place after the seminar about potential applications and technology enhancements. During my visit, I was also allowed to attend a seminar in which graduate students from the University of Edinburgh presented their work on a given topic. This was a learning experience that permitted me to see how students prepared and presented a research topic.

This experience opened my eyes to numerous possibilities from a student's point of interest. As students, we seek ways to help us learn to become productive and competitive engineers. International collaborations allow a student to gain this needed experience. I plan to use this experience to encourage other students to pursue an international internship or work related experience to enhance their education.

### FOREIGN SPONSOR EXPERIENCE

One of the key attractions associated with this travel grant for both UA and SMC was their complementary technology capability and so there was an excellent probability of a real collaborative programme resulting from the visit. The SMC is presently involved in 3-D interconnect via bump bonding hybridization [7] and a collaboration with UA would provide the potential to open up other opportunities. Importantly, the overhead associated with applying for funding and setting up the visit was low and enabled all parties to concentrate their efforts on better understanding the technologies and identifying possible research areas. The programme while at Edinburgh has been detailed above and provided the prospect for Edinburgh staff to examine a 3D interconnect technology and explore possible research options which was a very beneficial experience, especially for some of the more junior staff. As mentioned previously the authors are committed to submitting related integrated proposals to appropriate funding bodies and looking forward to the opportunity to work together on a project that both would struggle with if they attempted to undertake it on their own.

## V. SUMMARY

A travel grant program has been described that allows U.S. scientists and engineers to visit foreign countries with the purpose of initiating a joint project and the experiences of the awardee, a visiting doctoral student, and the foreign sponsor has been described. This has been a beneficial experience for all parties and the links resulting from the visit are being used as the basis for developing a collaborative programme to solve a complex problem related to 3D interconnects.

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## REFERENCES

[1] Winkler, G., Virga, K. L., Prince, J., "Improving Graduate Packaging Education through International Cooperation," *Proc. ECTC* ., 2003, pp. 508-513.
[2] De Kryger, W. J., Lopez, D. A., "Collaborative Engineering Education: an International Teaming Approach," *Proc. ASEE Conf.*, 1998.
[3] Erden, A., Erkmen, A. M., Erkmen, I., Bucinell, R. B., Traver, C., and Notash, L., "The Multidisciplinary International Virtual Design Studio (MIVDS)," *IEEE Trans. Education,* Vol. 43, No. 3, 2000, pp. 288-295.
[4] www.aaas.org/programs/international/wisc/
[5] http://www.nsf.gov/home/int/
[6] Brainard, S., "Globally Diversifying the Workforce in Science and Engineering," *Proc. International Symp. Technology & Society,* 1999, pp. 54-59.
[7] Walton, A.J., Parkes, W., Terry, J.G., Dunare, C., Stevenson, J.T.M., et al., "Design and Fabrication of the Detector Technology for SCUBA-2," *Proc IEE*, Vol. 151, No. 2, 2004, pp.110-120.