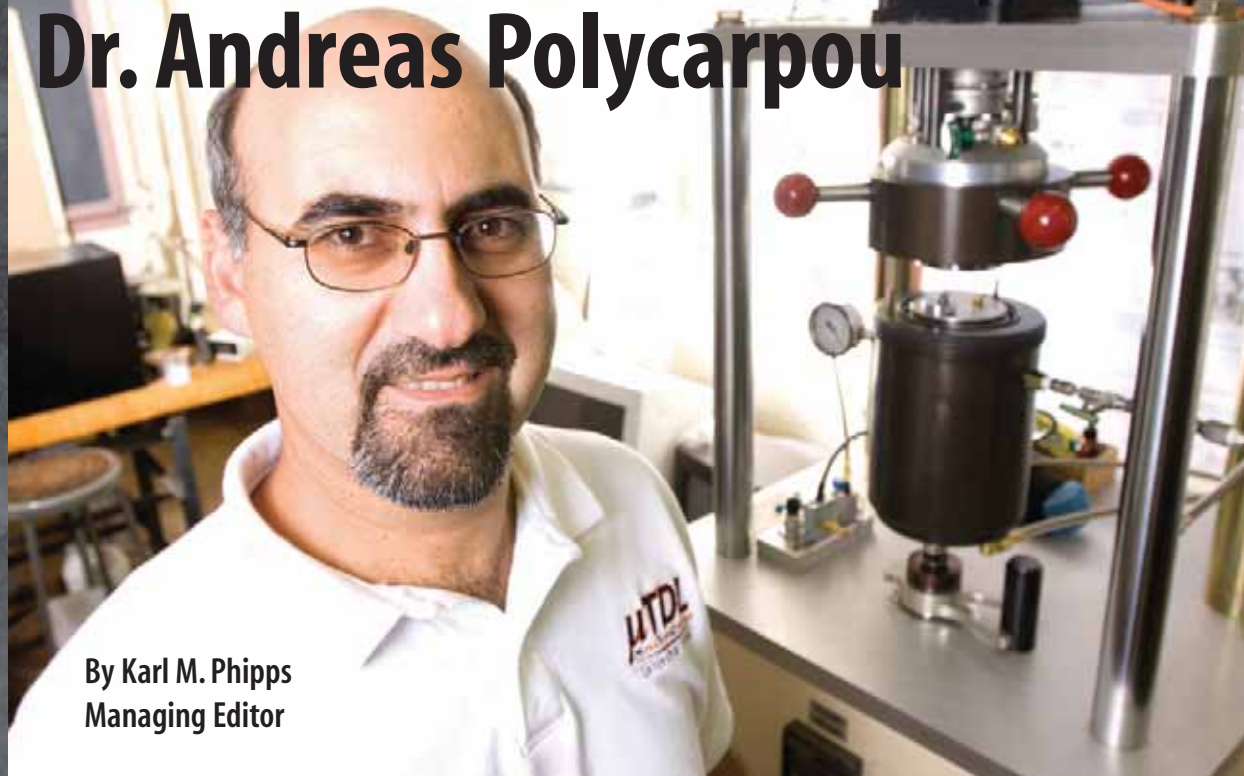




20 Minutes With...

Dr. Andreas Polycarpou



By Karl M. Phipps
Managing Editor

This mechanical engineering professor from the University of Illinois is dedicated to his profession and enjoys teaching and mentoring the next generation of future tribologists.

Professional experience

- University of Illinois at Urbana-Champaign, Urbana, Ill., Dept. of Mechanical Science and Engineering, Associate Professor, 2005-Present.
- University of Illinois at Urbana-Champaign, Urbana, Ill., Dept. of Mechanical Science and Engineering, Assistant Professor, 1999-2005.
- Seagate Technology, Bloomington, Minn., Staff Scientist, 1997-1999.
- Technion-Israel Institute of Technology, Haifa, Israel, Dept. of Mechanical Engineering, Postdoctoral Fellow, 1995-1997.
- The State University of New York (SUNY) at Buffalo, Buffalo, N.Y., Dept. of Mechanical and Aerospace Engineering, Visiting Lecturer, 1995.

Education

- The State University of New York (SUNY) at Buffalo, Buffalo, N.Y. Doctorate in Mechanical Engineering, 1994.
- The State University of New York (SUNY) at Buffalo, Buffalo, N.Y. Master of Science in Mechanical Engineering, 1992.
- The State University of New York (SUNY) at Buffalo, Buffalo, N.Y. Bachelor of Science in Mechanical Engineering, 1990.
- Higher Technical Institute (HTI), Nicosia, Cyprus. Higher National Diploma in Mechanical Engineering, 1986.

Professional affiliations

- STLE
- ASME
- Conference Planning Committee Member, ASME/STLE International Joint Tribology Conference, 2003-Present.
- Editorial Board, *Review of Scientific Instruments*.

- Associate Editor, *ASME Journal of Tribology*.
- Editorial Board, *Microsystem Technologies*.

Awards and honors

- STLE Edmond E. Bisson Award, 2007.
- Fulbright Award for a U.S. Citizen to Cyprus, J. Williams Fulbright Foreign Scholarship Board, 2007.
- Xerox Award for Faculty Research, College of Engineering, UIUC, 2007.
- Kritzer Faculty Scholar, Dept. of Mechanical Science and Engineering, UIUC, 2006-2009.
- Xerox Award for Faculty Research, College of Engineering, UIUC, 2005.
- National Science Foundation Faculty CAREER Award, 2003.
- ASME Burt L. Newkirk Award, 2001.
- Reviewer of the Year Award, *ASME Journal of Tribology*, 1997.

Why did you decide to specialize in microscopic/nanotribology rather than go into more traditional tribology fields like automotive and aerospace?

There are several reasons I decided to specialize in microscopic/nanotribology. Most important, it is a very exciting and emerging field that can significantly impact society. Having said that, let me say that circumstances also played a role in my specialization in this area. In 1995 I joined professor Izhak Etsion, a STLE lifetime member, at the Technion-Israel Institute of Technology as a postdoctoral working on mechanical face seals.¹ I also worked on a stiction model applicable to magnetic storage head-disk interfaces.²⁻³ That work involved adhesive interactions and molecularly thin lubricants that could be classified as micro/nanotribology. I was particularly intrigued by the fact that we (as engineers) had to account for intermolecular interactions and nanometer scale roughness for realistic devices (such as hard disk drives).

In 1997, while interviewing for several academic positions in the United States, I received a call from a former fellow postdoctoral friend at Seagate Technology. He suggested that I might also be interested in interviewing with the company. Fate had it that between university interviews, I was able to interview with Seagate. After talking with them about the tribological and system dynamics (such as shock-induced contact) issues associated with magnetic storage devices, I got very excited about this field. The feeling was mutual, and Seagate made me an offer on the spot. I took the job, and for two years I worked on many different aspects of magnetic storage tribology and enjoyed the fabulous environment and professional interaction with my fellow tribologists and friends there.

The experience not only got me hooked on this field, but I could also clearly relate the micro/nanoscale aspects of this work to actual engineering devices well beyond magnetic storage. I love working on complex problems, and there is nothing more exciting than when I get mathematics and physics to agree with realistic experimental results. The field of tribology, which focuses

on micro/nanoscales but is at the same time applicable to realistic devices, offers me this opportunity. I also work on traditional tribology, especially tribology of compressor surfaces. I am one of those researchers who work across different tribology length scales, such as coupling with system dynamics, as I believe that there are many lessons to be learned from traditional fields that apply to the micro/nanoscales and vice versa.

How do you balance your time working with students while doing research and volunteer work in the tribology community?

Those are the three things I love most about my work. What I do everyday is what I love, and I am passionate about it. I am very fortunate to have a job I love to do and get paid for it. Balancing the three “essentials” of the academic profession is not too difficult, as I view my students (both undergraduate and graduate students) as an integral part of my research. I have been very fortunate to work with exceptional students during my eight years at UIUC. They are superb and excellent independent researchers, which makes my work very enjoyable. When it comes to volunteer work in the tribology community, I not only enjoy the contributions I make, but I view the tribology community as my extended professional family.

When I was first starting my career, the tribology community offered me opportunities, and, most important, its leadership placed a lot of trust in me. This helped me grow to the point that working with other tribologists, as well as helping young tribologists, is very important to me. In addition, I also care tremendously about tribology and its future, so I believe it is my duty and obligation to promote this field as much as possible. I believe that to be effective we need to work at the professional level and be involved in policy-making. We need to get young engineers involved and empower them. Lastly, we need to open our laboratories to the public and

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What advice would you give students who are interested in pursuing a career in tribology?

If I can only advise and influence students who are already interested in tribology, then I believe it is too late to make an impact and further advance our discipline. I think the tribology community is a great nurturing family for students and incoming engineers. Senior researchers and professional tribology societies like STLE and ASME's Tribology Division do a good job mentoring aspiring engineers. The best advice I could give to students is very simple. The area of tribology and interfacial interactions is a very dynamic and interdisciplinary field that cuts across many different areas and length scales. It is a lot of fun and rewarding to work in this field, especially if you are passionate about what you do. Being passionate will almost certainly guarantee that you will have fun and be successful.

What are your thoughts in promoting tribology and engineering in general, especially to the young generation?

I would like to step back for a second and look at the need to reach out to children at an early age, to expose them to and get them excited about tribology and engineering in general. We need to reach out to them when they're still in elementary school and certainly in middle and high school. We need to find ways to get them involved (not just "talk to them") so they can experience the exciting aspects of engineering and science. At the college level, we need to better present our discipline to engineering students and encourage them to pursue studies and careers in tribology. By saying that, I realize I am falling into the same pitfall of encouraging and telling others about tribology, which does not seem to have worked effectively over the years.

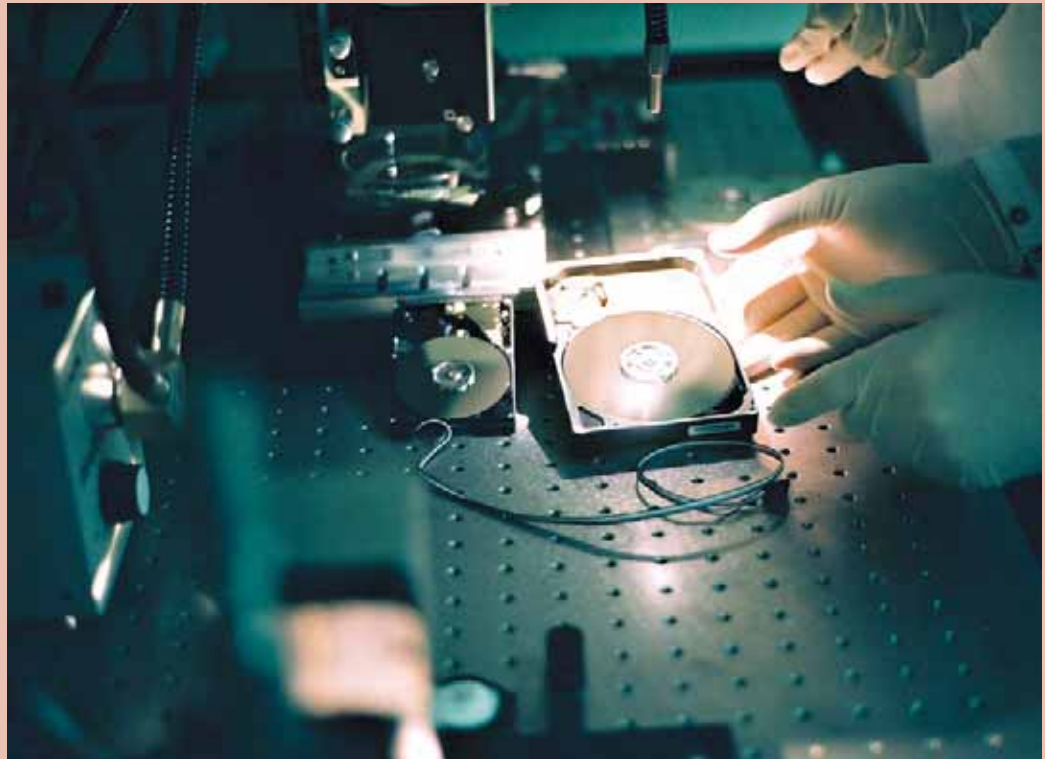
Instead we need to engage students, we need to re-examine the way we present tribology to ourselves, among other things. The great need in this area was best cap-

tured by the inventor of the word "tribology," Dr. H. Peter Jost, during his speech in 2005 at the third World Tribology Congress in Washington, D.C.,⁴ where he stated, "As your International Tribology Council president, I therefore say, let us produce the means required to storm the bastions of ignorance of our subject and defeat the conservatism opposing tribology recognition, thus enabling tribology permanently to take its rightful place for the advantage of industry in many directions, health and safety, sustainability, energy preservation and the alleviation of suffering, all for the benefit of national wealth creation and health improvement."

We need to make fundamental changes in the way we approach, reach out and educate young people. Like it or not, the word "tribology" itself does not seem to appeal to non-tribologists. However, the disciplines of interfaces, solid mechanics, nanomechanics, fluidics and materials (which are all part of tribology in some respect) are very popular among students.

Tell us about UIUC's Microtribodynamics and Tribology Laboratory. What areas of research are involved?

When I came to UIUC in 1999, I was ready to tackle some complex issues associated with interfacial tribological phenomena in microdevices such as magnetic storage head-disk interfaces and microelectromechanical systems. There were several aspects of this problem I felt were very important but were not yet being particularly and systematically investigated, like the effect of surface roughness and the effect of intermolecular adhesive interactions and their coupling to system dynamics. Thus, I coined the word "microtribodynamics" (defined as the study of friction, adhesion and dynamic interaction in miniature systems). I was awarded the NSF CAREER Research Award based on the investigation of some aspects of microtribodynamics. The systematic approach/framework that we originally developed for microdevices⁵ also can be generalized to



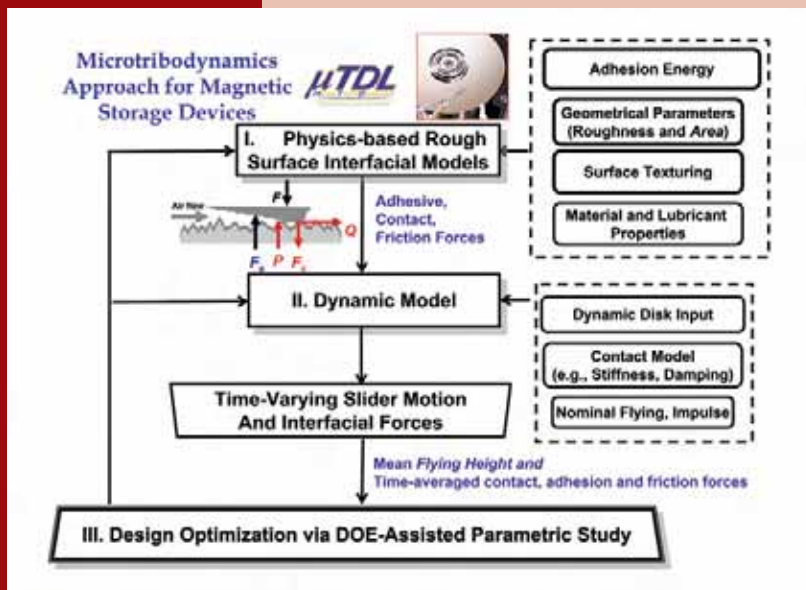
A microscale experimental setup for magnetic storage research.

Figure 1. Schematic diagram of the microtribodynamics approach for magnetic storage devices.

other tribodynamical systems. The schematic (see Figure 1) shows the microtribodynamics approach as applied to magnetic storage. The approach aims to develop physics-based interfacial models that measured parameters, such as roughness, nanomechanical properties and molecularly thin lubricant properties, to predict friction, adhesion and contact forces.

These forces then enter into a dynamic system model that describe the tribointerface and associated structures to predict dynamic motions and forces. Lastly, practical design guidelines and optimization is carried out via Design-of-Experiments/ANOVA parametric studies. This approach is “modular” and can incorporate different models as they become available. Experimental verification is conducted at various stages. The approach led us to some exciting research areas such as (a.) the development of continuum-based contact adhesive models under dry and wet environments,⁶⁻⁸ (b.) nanomechanical property measurements of ultrathin coatings and surface layers, where we have developed prototype instrumentation to perform sub-nanometer indentation measurements,⁹ and (c.) accurate topographical measurement and description of surfaces.¹⁰⁻¹¹

In addition to the microtribodynamics-related research, we also conduct research on general tribological problems. When I came to UIUC, I found an amazing collegial environment and numerous possibilities for collaborations, as well as superb experi-



mental facilities and resources such as the Center of Microanalysis of Materials.¹² Moreover, UIUC houses the Air-Conditioning Refrigeration Center,¹³ which includes approximately 30 member companies, including the major air-conditioning and refrigeration compressor manufacturers. Within this environment we embarked into the understanding of scuffing phenomena and recently on the tribology of carbon dioxide that is a potential replacement of current environmentally harmful refrigerants.¹⁴ It was this particular paper for which we were recognized with the prestigious 2007 STLE Edmond E. Bisson Award. Also, we have been conducting tribology research of advanced protective coatings for compressor and other advanced engineering applications, as well as tribology of rails and automotive constant velocity joints.

Your research deals predominantly with nanosurfaces and magnetic media tribology. Are there similarities between your work in other industries?

As I mentioned before, my work on scuffing and recent activities on protective coatings for engineering surfaces is directly geared toward conventional engineering applications. Some of the lessons we learned from our studies at the micro/nanoscales are directly applicable to advanced engineering surfaces for conventional applications. To this end, I have been forming partnerships with regional industries such as Emerson Climate Technologies Inc. (formerly Copeland Corp.) and with Caterpillar, which hired three of my former graduate students.

What kinds of future projects are you currently working on?

I have two projects in the works. The first is a partnership with material science researchers in developing and testing tailored protective coatings for general tribological applications, including high-temperature applications (up to 1,000 C). The second area is on reversible adhesion for smart applications (manipulating the surfaces to achieve strong bonding that can reverse very quickly, if necessary).

What part of your work do you enjoy the most?

It is hard to identify a specific aspect that I enjoy the most, as I truly enjoy every aspect of my work, whether it's teaching, research or volunteer service. However, if I were to identify one aspect of my work that I not only enjoy now but could also see myself enjoying for years to come, that would be my interaction with graduate students. It is very rewarding to see the tremendous growth in these young individuals who start at the apprentice level and quickly rise to become professional colleagues of mine. As my graduate students know, in order to graduate they need to surpass my own knowledge in their specific field/sub-field of study. I have been fortunate to work with about two dozen graduate students so far, and more than half of them have graduated and moved into careers in industrial and academic positions. Seeing their success beyond their graduate studies is perhaps the most rewarding experience of my professional career.

Another aspect of my work that I enjoy is the teaching of engineering and tribology to the younger generation. During the last several years, my group has conducted scientific research and outreach activities in conjunction with the Cub Scouts' pinewood derby car race. We developed a brochure explaining friction reduction and other engineering principles that are widely disseminated. We have also published the first journal paper related to the pinewood derby car educational/outreach activities¹⁵ and have another paper in the works.

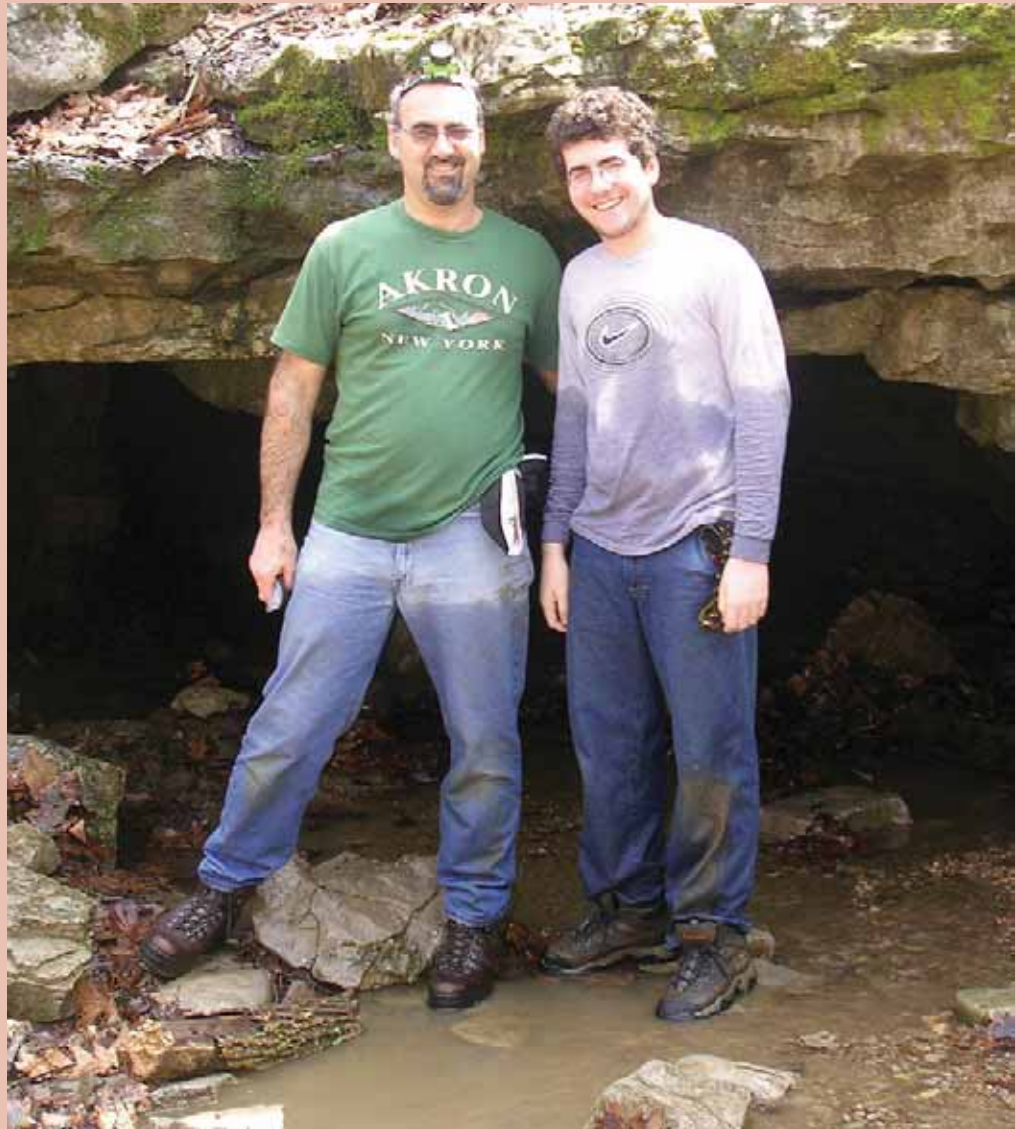
If you weren't a tribologist, what other type of occupation would you have pursued?

As a youngster I developed a passion for animals and an interest in archeology. Growing up in Cyprus, which is the third-largest island in the Mediterranean Sea and has a very long and rich history spanning at least 10,000 years, gave me a lot of opportunities to learn about archeology. However, I needed to pursue an occupa-

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It is a lot of fun and rewarding to work in this field, especially if you are passionate about what you do. Being passionate will almost certainly guarantee that you will have fun and be successful.



Outside of the classroom, Andreas enjoys spending time traveling with his family and participating in various outdoor activities. Pictured is him along with his son, Arie outside of Wolf Cave at McCormick's Creek State Park in Spencer, Ind.

tion that was more practical and guaranteed a job, so I decided to pursue engineering. During my first semester of graduate school, I decided to take a class on Environmental Acoustics with professor Andres Soom. I liked the field, as it was a blend of engineering and perception as it relates to everyday life (unwanted noise) as well as to desirable acoustics (sounds). Professor Soom was a person with an in-depth understanding of science as it relates to practical matters, and he was also very approachable. It did not take a lot of convincing from him to persuade me to pursue a doctorate in tribology. To be

more specific, my doctorate was on friction/vibration interaction or, as I usually like to put it, interfacial problems coupled with dynamics. My studies with professor Soom gave me a lot of freedom, something I believe helped me go into areas that really got me excited!

Do you have any interesting hobbies that you participate in your personal life?

My hobbies are centered around my family, outdoor activities and nature. I am active in a local Boy Scout Troop. I enjoy outdoor camping, especially under inclement weather conditions. The aspect of being out there

with the elements with no home conveniences offers something that makes me humble and reverent. At a recent outing at Bluespring Caverns in Bedford, Ind., my 13-year-old son, Arie and I crawled through an approximately 2-by-2 foot opening, which was quite an experience. We also crawled through Wolf Cave at McCormick's Creek State Park in Spencer, Ind. In addition, every summer my family and I spend time in Cyprus where we enjoy the wonderful Mediterranean weather, archeology and excellent food. Perhaps one day I will organize a tribology conference in Cyprus, and you will all be welcome! <<

You can reach Andreas Polycarpou at polycarp@uiuc.edu.

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