

# MATERIALS SCIENCE AND TECHNOLOGY NEWSLETTER

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## **FOCUSING ON SURFACE RELATED ASPECTS OF MATERIALS SCIENCE**

### **IN THIS ISSUE**

<b>EDITORIAL NOTES</b> . . . . .	2
Fads and Fashion in Science and Technology or is NANO over yet?: . . . . .	2
<b>FEATURES</b> . . . . .	4
Better Days Ahead: Recovering from Y2K, 9/11, Dot Com, and SARS in 2005 . . . . .	4
Surface Science and the Coming Hydrogen Economy . . . . .	6
<b>BOOK REVIEWS</b> . . . . .	8
Molecular Adhesion and Its Applications: the Sticky Universe . . . . .	8
Polymer Surface Modification: Relevance to Adhesion Volume 3 . . . . .	9

### **EDITORIAL NOTES**

#### **Fads and Fashion in Science and Technology or is NANO over yet?:**

As a young undergraduate aspiring toward a career in physics I was under the sophomoric impression that the realm of science and technology was somehow immune from phenomena which characterize the general activities of society at large. The Fashion Industry, for example, is clearly characterized

### **CURRENT SYMPOSIA: . . . . . 10**

#### **Preliminary Program**

#### **FIFTH INTERNATIONAL SYMPOSIUM ON POLYMER SURFACE MODIFICATION: RELEVANCE TO ADHESION**

To be held June 20-22, 2005  
NOVOTEL, Toronto Centre,  
Toronto, CANADA . . . . . 10

#### **Preliminary Program**

#### **FIFTH INTERNATIONAL SYMPOSIUM ON SILANES AND OTHER COUPLING AGENTS**

To be held June 22-24, 2005  
NOVOTEL, Toronto Centre,  
Toronto, CANADA . . . . . 14

### **REGISTRATION INFORMATION . . . . . 17**

by the need to constantly create new styles in apparel if for no other reason other than to stay in business. Women's hemlines must go up and down year by year in order to keep the inventories of the garment industry moving. Even the supposedly technology driven auto industry is fully captive to this behavior. I once had a professor of mechanical engineering tell me that there have been no fundamental technical advances in automobiles since the 1930's when the hollow crankshaft was invented. Every year it's a matter of rearranging the sheet metal. Make it longer or

lower. Change the colors or redesign the interior. In the end it's still 4 round wheels mounted to a frame and powered by an internal combustion engine. The main focus remains to create the image of something new that everyone has to have in order to keep the inventories of the auto industry moving.

Ah, but within the realm of science things are different. Here it is the never ending struggle to unlock the secrets of nature that provide the focus of all effort. The natural world has no need for fad or fashion. It operates under the direction of immutable laws which dictate all natural behavior from the motion of the planets down to peregrinations of atomic and subatomic particles. The scientist is not at liberty to state that this year all matter follows Newtonian mechanics and next year quantum mechanics takes over simply to supply the technical journals with new material. Furthermore, having established quantum mechanics as the correct theory of atomic matter there is no going back to Newtonian mechanics simply to invoke a new fashion. The next move will be dictated by nature and, since nature does not give press conferences, this can only be determined by diligent ongoing research and experimentation.

It all seems so logical and self evident that one scarcely spends much time thinking of it especially when laboring mightily with more weighty matters such as completing a thesis so that one can graduate and go on ever more interesting projects. Alas the time eventually comes when having graduated the prospect of finding employment in the outside world looms heavily on the horizon. It is at this time that the gods of fad and fashion re-insinuate themselves, for it turns out that fad and fashion are among the fundamental driving forces which shape human economic and social behavior. As a student one typically is not weighed down with social and economic responsibilities such as supporting a family or looking after aging parents. All of this, however, bears down very rapidly once faced with leaving academia for the real world. Further, it does not matter whether one contemplates going on to academia as a professor or to industry as an engineer. The professor, though under looser constraints, must nevertheless teach relevant material to his/her students and obtain support either from industry or government for ongoing research.

The engineer must rapidly assimilate to the cultural environment of the company. Within the realm of Physics, for instance, the decades of the 1950's-60's were dominated by solid state physics (to support the burgeoning electronics industry) and nuclear physics (to support the military and the power industry). These fields have waned recently in favor of more fashionable fields such as biotechnology, not because all relevant problems were solved, but because the needs and desires of society at large changed.

This now brings us to the prime topic of this piece which is the current excitement over so called nano-technology. In the beginning there was MICRO. I remember working in the microelectronics industry in the mid 1970's when one micron technology was at the leading edge of what could be done with integrated circuits. Just imagine the wonderful devices that could be fabricated if you could control your line widths to one micron wide? That is all history now. Right now one micron lines look the same way wiring with 1 millimeter wires did then. The logical progression seems inescapable. If one micron technology could bring about all the microelectronic wonders we saw during the decade of the 1980's just think what going to one nanometer could do? Again the social and economic needs of society at large bring fad and fashion to the fore. It was not as though scientists had not been working at the nano-scale before. Witness the 18<sup>th</sup> century work of the eminent Benjamin Franklin and his assistant Ms. Poccles on 1 nanometer monolayers. Monolayer work has been ongoing ever since and can truly be considered the first nano-technology. But who in those days really cared? My colleague Dr. Ben Kellner and I published on measuring the mechanical properties of monolayers in 1981. ("Detection of the Thermal-Mechanical Properties of a Monomolecular Film by Means of a Vibrating Reed", R. H. Lacombe and B. M. J. Kellner, **Nature**, 289, 661 (1981)) However, the gods of fad and fashion were not with us in those days so the work has gone largely unnoticed.

These days, however, so called nano-technology has come to the fore as "the next big thing", which brings up the question as to just what is nano-technology? It seems the question has two answers depending on your point of view. To the venture capitalist nano-technology is the next scientific wonder to

invest in to make huge profits as one did with microprocessors or internet companies back in the 1980's and early 1990's. From the point of view of the scientist, however, nano-technology implies understanding the atomic and molecular organization of matter on the scale of 1 to 100 nanometers ( $10^{-9}$  to  $10^{-7}$  meters). The bulk properties of just about every solid depends critically on how the constituent atoms or molecules are arranged at the nano-scale. Take a block of solid carbon for example. Arrange it in large single crystals with  $sp^3$  tetrahedral bonding and you get diamond. On the other hand, if the bonding at the nano-scale is  $sp^2$  then you wind up with graphite. One can take this a step further and make coatings with a mixture of both  $sp^2$  and  $sp^3$  bonding and create what is called diamond like carbon (DLC) a hard and very smooth material which can be used to coat plastic lenses to make them scratch resistant.

So there you have it. Taking a simple lump of carbon one can wind up with anything from a gemstone to a bag of soot depending on how things are arranged at the nano-scale.

Carbon may be a rather dramatic example of the consequences of atomic and molecular organization at the nano-scale but it is by no means an isolated case. Essentially all solid materials show a dramatic dependence on their nano-scale morphology. As another example let's look at silica glass  $SiO_2$ . In its fully crystalline form one has quartz which is a piezoelectric crystal commonly used in digital watches or in thin film thickness monitors. Melt the crystal and rapidly cool it you get the amorphous morphology which is basically common glass as found in windows or table ware depending on the impurities that are added. However, one can also form 3 to 4 nanometer spheres from silica which when appropriately fused together can form what is known as an aerogel, a fascinating very low density material that being mostly air insulates better than mineral wool and has a higher heat resistance than aluminum.<sup>1</sup>

Again we see that molecular organization at the nano-scale brings about literal miracles in

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<sup>1</sup> For more details on this fascinating material see the article "Less is More with Aerogels", Eric Lerner (The Industrial Physicist, October-November 2004) p. 26

terms of ultimate bulk properties. Thus, whereas the venture capitalist is looking to make a quick profit in nano-technology, it is the scientist and engineer that will make it happen through research and experimentation which lead to a deeper understanding of the subtle link between nano-scale morphology and the ultimate bulk properties of materials. The one is chasing the current fashion the other simply continuing work that has been going on for at least a century. However, the two need each other. The work of the scientist has to be relevant to the current needs and desires of the society that supports him and the capitalist must rely on the scientist to develop the required knowledge and understanding which is vital to making it all work.

So is NANO over yet? Hardly. Rather it has been going on for quite some time and has just recently been rediscovered. The capitalists are now discovering that turning a quick shilling in the nano-field is not so easy since much fundamental understanding is still lacking. Therefore, the fad and the fashion may eventually fade. However, for the scientist the fun has just begun.

## FEATURES

### **Better Days Ahead: Recovering from Y2K, 9/11, Dot Com, and SARS in 2005**

The early years of the 21<sup>st</sup> century have certainly left much to be desired for those who try to organize international symposia. The year 2000 wasn't that bad. Despite all the anticipation of a global meltdown of computer systems due to the infamous Y2K bug nothing really happened. The year 2001 was another matter. The horrendous terrorist attack on the World Trade Center hit hard. MST had 4 meetings planned at a hotel in Newark New Jersey. Two in the month of October and two in November. After the attack both October symposia had to be canceled due to an avalanche of cancellations. By rights the November symposia should have been canceled also but the ever popular symposium on Polyimides and High Temperature Polymers was held anyway since a fair number of participants from Europe planned to come despite the near panic atmosphere prevailing at that time. Many of these people are our friends and colleagues and if they were willing

to come from Europe we should at least come from New York. However, a meeting that had nearly 60 papers scheduled was reduced to 20. The meeting was a success despite the drop off in participation but there was an eerie air about it. The hotel where the meeting was held was located so that one could clearly see the World Trade Towers across the Hudson River from the lobby. An air of disbelief hung over one while checking in and, while looking over the river, finding that the twin towers were no longer there.

The year 2002 turned out to be little better than 2001 due to the so called dot com bust which precipitated a disastrous drop in the stock market. International travel nearly dried up as companies everywhere tried to save money by restricting nonessential expenses such as attending technical symposia. The negative effect on conferences was immediately apparent and a few of the larger conferences folded. MST survived essentially because it is small and highly flexible. We planned to make a comeback in 2003.

Did you ever hear the old saying that trouble never comes as isolated events but in bundles. The year 2003 proved that rule for MST since we had two very successful symposia scheduled to be held in June in Toronto Canada. This time the disaster was not the collapse of the World Trade Center but the announcement by the World Health Organization that Toronto was somehow at the epicenter of the global SARS epidemic!

Now it turns out that in 2003 far more people died of auto accidents in Toronto than from the SARS virus but that did not prevent the city from being globally blacklisted as a destination to be avoided except for the most critical business needs. Many companies had blanket travel bans on going to Toronto except for absolutely essential business purposes and many universities followed suit. The net result was another avalanche of cancellations which effectively forced us to cancel the June meetings.

There was also another aspect to the SARS disaster that was more curious than sinister. In the early months of 2003 it was hardly noticed. I happened to follow the progress of the epidemic in the pages of NEWSWEEK magazine. In week one the story broke as a

two paragraph note in the Science section noting that there were concerns over a possible virus epidemic emanating from South East Asia. Hardly much to be concerned over. In week two, however, SARS took over the entire Science section and the city of Toronto was mentioned as a possible hot spot. SARS had now started to take on all the aspects of a wild fire which starts off as an insignificant flicker and rapidly turns into an immense conflagration. This was quickly proved to be the case as in week three the SARS epidemic moved from the Science section to the front page of NEWSWEEK! And what a conflagration it was. The lead article was devoted entirely to the SARS problem with multiple photographs showing doctors and panicked individuals running hither and thither all wearing surgical masks for protection. The city of Toronto was now identified as one of the major focal points of the crisis. Going by the lurid photographs and alarming prose one would have to wonder whether anyone in the city would be left alive.

Of course the situation on the ground in Toronto was nothing like the media hype. In terms of everyday life nothing had changed. The only real problem was the downturn in tourism precipitated by the bad publicity.

One final interesting aspect of the SARS fiasco is that it illustrates a curious feature of the cooperative collective behavior of interacting systems. I have a special interest in this type of problem since I wrote my doctoral thesis on the cooperative collective behavior of polymer chains. One of the distinct signatures of this type of phenomenon is that, under the correct conditions, strictly local interactions can give rise to dramatic global behavior such as phase transitions whereby the system radically changes from one form to another. The schooling behavior of fish is a clear example of this type of behavior in animal populations. The fish in a school are so closely packed that each one determines its course by watching what its immediate neighbors are doing. The net result is that the motion of the entire school is controlled by the motion of a small number of fish at the leading edge. Similar behavior arises in human populations since people are sensitive to what their neighbors are doing and tend to follow suit. The behavior of densely packed crowds is a clear example of this as evidenced by the riots that break out from time to time at large sporting events and

rock concerts. I maintain that the SARS epidemic in Toronto followed the same pattern. People interact indirectly with each other through the global news media. The interaction may be indirect but it is still there and under the right circumstances cooperative collective behavior can ensue as illustrated by the SARS phenomenon.

### **Surface Science and the Coming Hydrogen Economy**

Since the editorial article of this issue deals with the current interest in nano-technology it is relevant to discuss further the connections between surface science, nano-technology and the major problem of the world's energy resources. As is well known, all of the advanced societies on the planet have an inordinate dependence on fossil fuels to supply the energy required both to keep the lights on and to simply move about. The need for abundant and cheap energy resources can hardly be overstated in terms of maintaining the standard of living of any society. I once read an article that described energy as a sort of natural currency in the sense that nothing can happen without it. One can easily argue that every major advance in human society has been associated with mankind's ability to more effectively and efficiently harness the planet's energy resources. The implementation of electrical power toward the end of the 19<sup>th</sup> century, for example, enable the development the large urban centers which we now take for granted. Cut off the electricity and all of the major cities of the world will shut down in short order.

Now the problem we face going forward into the future is not that there is insufficient energy on the planet. No, there is plenty of energy in the environment. The problem is that we are not clever enough to effectively and efficiently get at it due to our lack of fundamental understanding of the nature of matter and energy at the atomic and molecular level. When the ancient Egyptians were erecting the pyramids some three millennia ago there was the same amount of energy in the environment at that time as there is now. However, since the Egyptians knowledge of materials and the basic forces of nature was so primitive, they had to make due with the only form of energy they knew which was animal and human muscle power. Even though we

have a much better grasp of these matters, today we still find ourselves in a situation analogous to that of the ancients. Despite our limited use of nuclear and solar power, we are overwhelmingly dependent on fossil fuels as our main energy source. Furthermore, the massive use of fossil fuels has become the source of major environmental problems which degrade the standard of living for nearly everyone.

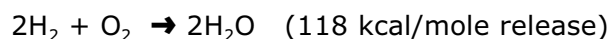
However, as stated above, there is abundant energy available if we are only clever enough to know how to tap it. One source is the large supply of hydrogen available on the planet which can be effectively burned in fuel cells. The nice feature of burning hydrogen is that it combines directly with oxygen to give off some energy plus water as a waste product. Thus you have what is essentially a totally non polluting energy source. Fuel cells can be used to burn many other potential fuels such as methane or ethanol but then one of the waste products is carbon dioxide which is a source of environmental problems.

So why, you might ask, are we not already burning hydrogen in fuel cells? The major reasons are at least twofold, one being the social-political aspect of the problem which we don't want to get into here. The other issues are the technical aspects of storing, distributing and burning hydrogen in an efficient and economical manner. We will now focus on these problems since they are closely involved with matters of surface science and nano-technology.

Hydrogen gas is pretty ephemeral stuff and to store it at sufficiently high densities so as to be economical and effective requires enormous pressures and concomitantly heavy duty containers. If you want to use hydrogen to power your car, storing enough to be useful but not unduly increasing the weight of the vehicle, becomes a major problem. One possible solution is the use of metal hydride materials which can capture large amounts of hydrogen on their surface and thus allow for high density storage at much lower pressure than would otherwise be the case. So right away surface science comes to the fore. Find the right material which will loosely trap hydrogen on its surface so that it can be stored at high density and low pressure. One idea that comes to mind is a cleverly designed polymer with just

the right functional groups needed to trap the hydrogen and an appropriate backbone structure to allow the formation of a suitable nano-scale morphology which would allow for the free transmission of hydrogen gas.

An even more subtle surface related problem concerns the efficient burning of the hydrogen within the fuel cell itself. From a global point of view this simply amounts to reacting two hydrogen molecules with one oxygen molecule to produce two water molecules plus the release of 118 kcal/mole of energy according to the following elementary reaction:



The chemistry and physics of how this reaction proceeds within a fuel cell is a good deal more intricate than the above simple reaction would suggest. Since the main purpose of the fuel cell is to carry out this reaction in order to capture the 118 kcal/mole as electrical energy the cell is fabricated in the form of a sandwich structure. Hydrogen gas is fed in on what is called the anode side of the sandwich where it interacts with a very thin layer of catalyst material, typically platinum metal, which breaks the hydrogen molecule down into its constituent parts, i.e. two protons and two electrons. The details of how this occurs is a fascinating and involved problem in surface chemistry and surface physics. Thus surface science enters the process right from the beginning. Now, having created two protons and two electrons is just the start of the operation. Unless something else happens very quickly these constituents will rapidly recombine to form a hydrogen molecule again which is the more stable thermodynamic state. This does not happen in the fuel cell, however, since very close by on the opposite side of the sandwich, called the cathode side, much the same type of event is occurring to an oxygen molecule which has been injected there in the same manner as the hydrogen is fed to the anode.

Now the basic trick is this. Having decomposed the hydrogen molecule into two protons and two electrons, these components have to be rapidly separated before they can recombine. Within the fuel cell this is accomplished by two separate pathways. The catalyst material on the anode and cathode sides of the cell are

electrically connected through an external circuit. This might be an electric motor or a light bulb or other device. This serves the function of what is called the external load. While on the anode side the hydrogen molecule is being made to give up two electrons to the conductive catalyst, on the cathode side the oxygen molecule is split into two atoms each of which grabs two free electrons from the catalyst. Since the catalyst layers on each side are electrically connected through the load, the grabbing of the electrons by the oxygen atom creates an electric field in the catalyst which is nearly instantaneously (i.e. at close to the speed of light) transmitted to the anode side of the cell where it attracts away the two electrons that were created by splitting the hydrogen.

Having thus swept away the two electrons we are now left with the two protons which you can be sure are not going to idly stand by. This calls into action the center of the fuel cell sandwich which is a semipermeable membrane which separates the anode and cathode sides of the cell and further acts as a conduction path for protons only. The membrane is another of the small miracles of surface science and technology which make the fuel cell a reality. It has to properly support the catalyst, provide an insulating barrier to electron conduction while simultaneously allowing for proton transport via a rapid diffusion process. Our protons now try to catch up with the electrons they lost by diffusing through the membrane barrier to the cathode side. Upon reaching the cathode they find their wandering electrons attached to a highly activated oxygen atom to which they immediately react with to produce a stable water molecule thus completing the reaction.

Finally, what happened to the 118 kcal/mole of energy released in the overall reaction? This in effect got carried away with the electrons which dissipated it in the external load either driving a motor or lighting a light or whatever. Strictly speaking though, we should say that this energy went into the electromagnetic field that was created by the electron/proton charge separation. The electromagnetic field drives a current of electrons through the external device which is what eventually absorbs all of the energy released by the chemical reaction.

The main point to be gathered from the above discussion is that the heart of fuel cell technology involves some rather delicate and sophisticated surface science both for the storage and the burning of the hydrogen gas. If we are only clever enough to figure it out we should be able to perfect this process and move beyond the current fossil fuel economy to an energy rich and pollution free hydrogen economy of the future. If all goes well our grand children and great grand children will look on us as we now look upon the ancient Egyptians.

## BOOK REVIEWS

**Molecular Adhesion and Its Applications: the Sticky Universe**, Kevin Kendall, (Kluwer Academic/Plenum Publishers, New York, 2001)

Professor Kendall provides us with a most informative and delightful introduction to the phenomenon of adhesion at the atomic and molecular level. This book is to be strongly recommended as supplementary reading for advanced undergraduate courses on materials science or as a general reference for anyone curious about adhesion phenomena and its relation to the atomic and molecular forces which hold all matter together.

Professor Kendall organizes the book around what he call the "Three Laws of Molecular Adhesion" which can be succinctly listed as follows:

1. The interaction between all electrically neutral matter is attractive.
2. Foreign and contaminant materials significantly modify and reduce the interaction stated in law number 1.
3. The interactions governing all adhesion behavior between electrically neutral matter are very short ranged.

Professor Kendall does not explicitly include the qualifier that one must be working with electrically neutral systems (i.e. no free charges moving around) but this is tacitly understood. Coulomb interactions would most certainly violate all of the above laws with the possible exception of number 2.

All of the above laws, however, can effectively be derived from the quantum mechanical theory of van der Waals interactions. The simplest example would be two hydrogen atoms sitting in a vacuum. If the separation between the atoms is sufficiently large (say 10 or more atomic diameters) then the two atoms are simply unaware of each others presence since aside for the exceedingly weak gravitational attraction there is no interaction whatever between the two. This in essence implies law number 3. As the atoms approach closer to one another, however, a point is reached where each begins to recognize that the other has an internal structure consisting of a positive and negative charge separated by roughly 0.05 nanometers. Now, even though quantum mechanics tell us that we should view the hydrogen atom as a uniform cloud of electrical charge surrounding the proton nucleus, as the two atoms approach close enough they begin to detect each others fine structure. They begin to see each other as electrical dipoles. From classical electrostatics we know that two dipoles always attract each other as the inverse sixth power of their radial separation. Thus we establish law number one and further quantify the short range nature of law number 3. From this example law number 2 is obvious since the presence of a third atom such as oxygen will definitely disrupt the interaction between the two hydrogen atoms. In fact from our discussion of fuel cells above we know that they would be more strongly attracted to the oxygen atom than to themselves and thus form a water molecule as opposed to a hydrogen molecule.

Another feature of the book is Prof. Kendall's treatment of the historical aspects of the subject including the pioneering work of Obreimoff on the adhesion of thin mica sheets in 1930. This was one of the very first attempts to experiment with adhesion forces at the atomic and molecular level. This work was subsequently followed up on by Gilman, at the General Electric Laboratories in Schenectady, New York in 1960, who made improvements to reduce the effects of friction and plasticity. Further progress was made by Tabor and Winterton who greatly improved the sensitivity of the experiment by using multiple beam interferometry to measure the deflections and also greatly enhanced the control and accuracy of loading by using piezoelectric actuators. Such was the improvement in resolution that



now the presence of 0.7 nanometer layers of adsorbed moisture could be readily detected. Subsequently Israelachvili and Tabor managed to improve the level of sensitivity down from 5 to 1.5 nanometers.

These and other topics are covered quite ably in this volume. However, those looking for a lot of formulas will definitely be disappointed. The level of mathematical treatment is absolutely minimal which makes the volume more suitable as an introductory treatment designed to provide intuitive insight and a general appreciation for the topic of molecular adhesion.

On the down side the book is marred by a number of typos and misprints which will hopefully be purged in future editions.

**Polymer Surface Modification: Relevance to Adhesion Volume 3**, Ed. K. L. Mittal (VSP, Utrecht, 2004)

With the upcoming FIFTH INTERNATIONAL SYMPOSIUM ON POLYMER SURFACE MODIFICATION: RELEVANCE TO ADHESION; To be held June 20-22, 2005 Toronto, CANADA looming on the horizon it is apropos at this time to review the volume documenting the 4<sup>th</sup> symposium in the series which was held in Orlando, Florida in June 2003. In distinction to Prof. Kendall's volume reviewed above, this is a technical work definitely aimed at the graduate level student or the technical professional interested in pursuing or staying up to date on the latest work in the field of polymer surface modification. It should be noted that this not a proceedings volume as commonly understood but rather an archival volume intended to be a useful reference work into the indefinite future. Each paper has been peer reviewed by at least two well recognized workers in the field and the level of careful editing is at or above that found in the scientific literature at large.

The volume contains a total of 25 papers divided into three parts as follows:

- ▶ Part 1: Plasma surface Modification Techniques

- ▶ Part 2: Other/Miscellaneous Surface Modification Techniques

- ▶ Part 3: General Papers

The subject matter of the symposium papers deals with the following topics of current interest:

- ▶ Low pressure plasma treatment
- ▶ Atmospheric pressure plasma treatment
- ▶ Electrostatic modification of polymers
- ▶ Photon based modification methods
- ▶ Low energy ion treatment
- ▶ Photo-grafting and photo-curing
- ▶ Metallization of treated surfaces
- ▶ Wet chemical functionalization
- ▶ Polymer release surfaces
- ▶ Modification for improved paint adhesion
- ▶ Modification of gas barrier properties
- ▶ Application to polymer nanolithography

The above list is not exhaustive but does give a reasonable snapshot of the over all content of the book. A quick glance reveals that many of the topics deal with leading edge technologies which makes this volume eminently suitable for the researcher who is looking for advanced applications of existing surface modification methods and also for the researcher who wants to explore entirely new methods.

As an example of one of the more leading edge technologies discussed is the paper by Lyuksyutov et al entitled "A Novel Approach Based on Scanning Probe Microscopy for Nanolithography in Polymer Films". In this paper the authors demonstrate how one can develop patterns 50 to 100 nanometers wide by 0.2 to 100 nanometers high through the combined use of eximer laser radiation and atomic force microscopy. Here is yet another example of genuine nano-technology in action as applied to problems of sub micrometer fabrication.

Those interested in obtaining a copy of this volume can do so by visiting the publishers web site at ([www.vsppub.com](http://www.vsppub.com)) or, better yet, one can join us in Toronto this June for the fifth symposium in the series where copies of this volume will be available at the registration desk and the very latest topics in the field will be actively discussed during the meeting.



## CURRENT AND FUTURE SYMPOSIA:

### PRELIMINARY PROGRAM FIFTH INTERNATIONAL SYMPOSIUM ON POLYMER SURFACE MODIFICATION: RELEVANCE TO ADHESION; To be held June 20-22, 2005; NOVOTEL, Toronto Centre, Toronto, CANADA

This symposium continues the tradition set by the first in the series entitled: "Polymer Surface Modification: Relevance to Adhesion" which was held in Las Vegas, NV, 1993. As with its predecessors, this symposium will be concerned with the technological areas where surface modification is a key technology which allows for the processing and manufacture of products which would otherwise be unobtainable. Proper adhesion characteristics are vital to the success of any practical implementation of polymer materials. Though polymers are generally not very adhesionable, proper surface modification can result in greatly improved adhesion without altering bulk properties. This symposium is organized to bring together scientists, technologists and engineers interested in all aspects of polymer surface modification, to review and assess the current state of knowledge, to provide a forum for exchange and cross-fertilization of ideas and to define problem areas which need intensified efforts. The invited speakers have been selected so as to represent widely differing disciplines and interests, and they hail from academic, governmental and industrial research laboratories. This meeting is planned to be a truly international event both in geographic coverage as well as in spirit. The following **partial** list of papers gives an indication of the scope of the program which ranges from novel surface treatment methods to applications to biopolymer materials to radiation treatments including laser, ultraviolet and energetic particles. Please note that the address given may apply only to the highlighted speaker.

### NOVEL SURFACE TREATMENT METHODS

**Carl Lawrence Aronson**, Douglas Beloskur, Bryce Burland, Jared Perez, Ali Zand, John M. Kokosa and Lars Guenter Beholz; Kettering University, Flint, MI 48504; **New Pathways for Modifying the Surface of High Density Polyethylene: Chemically Benign Adhesion Promotion and Subsequent Functionalization**

**Hans-Jürgen Buschmann** and Eckhard Schollmeyer; Deutsches Textilforschungszentrum Nord-West e.V., Adlerstrasse 1, D-47798 Krefeld, GERMANY; **Dendrons for the Surface Modification of Polymeric Materials**

**M. Ghoranneviss**, B. Moazzenchi, S. Shahidi, R. Rashidi, H. Hosseini and Amir H. Sari; Plasma Physics Research Center, Science and Research Campus, Islamic Azad University, Tehran, IRAN: **Decolorization of Denim Fabrics with Cold Plasma in The Presence of a Magnet Field at Various Times**

**E. Schollmeyer**, J. Zorjanovi,, R. Zimehl, O. Petravic, W. Kleemann, T. Textor, Th. Bahners and D. Knittel; 1) Deutsches Textilforschungszentrum Nord-West e. V., 47798 Krefeld, GERMANY; **Synthesis of Superparamagnetic Filaments**

**Liang Hong**; Department of Chemical & Biomolecular Engineering, National University of Singapore, 4 Engineering Dr 4, Singapore 117576, SINGAPORE; **Creating Regularly Arrayed Pores on Polystyrene Thin Film as a Micro-Reactor**

**E. Schollmeyer**, D. Knittel, T. Textor, T. Bahners, R. Zimehl and J. Zorjanovi; Deutsches Textilforschungszentrum Nord-West e. V. Adlerstr. 1, 47798 Krefeld, GERMANY; **Nanotechnology to Functionalization of Textile Materials**

**Thomas Schuman**, Maninder Singh, and James Stoffer; University of Missouri-Rolla, Department of Chemistry and Materials Research Center, Rolla, MO 65409; **An In-mould Application of Adhesion Promoter to Polyolefin Substrates**

## BIOPOLYMER APPLICATIONS

**Rashidul Alam**, M Ibrahim H Mondal & Mubarak A. Khan; Radiation and polymer Chemistry Laboratory, Institute of Nuclear Science and Technology, Bangladesh Atomic Energy Commission. P.O. Box 3787, Dhaka, BANGLADESH; **Roll of 3-(trimethoxysilyl) Methacrylate on the Improvement of Chitosan Film by Photocuring**

Dierk Knittel, **Hans-Jürgen Buschmann** and Eckhard Schollmeyer; Deutsches Textilforschungszentrum Nord-West e.V. (DTNW), D-47798 Krefeld, FRG; **Functionalization of Fiber Surfaces by Thin Layers of Chitosan and Related Carbohydrate Biopolymers and Antimicrobial Activity of Surfaces**

**Ezequiel Delgado**; Graham G. Allan; Angel Andrade, Héctor Contreras, Higinio Regla and Guillermo Toriz; Department of Wood, Cellulose and Paper, University of Guadalajara, P.O. Box 52-93 45020 Zapopan, Jalisco, MÉXICO; **On the Chemical Modification of Cellulose Fibres Using Triazine Chemistry: from Fiber-reactive Dyes to Molecular Encapsulation**

**M. Ghoranneviss**, D. Dorranean, S. Shahidi, B. Moazzenchi, A. Rashidi, H. Hosseini and Amir H. Sari; Plasma Physics Research Center, Science and Research Campus, Islamic Azad University, Tehran, IRAN; **Investigation of Antibacterial Acting on Cotton Fabrics with Cold Plasma in the Presents of Magnet**

**P. Jovancic**, R.Molina, E.Bertran, D.Jocic, M.R.Julia, P.Erra; Textile Engineering Department, Faculty of Technology and Metallurgy, University of Belgrade, YUGOSLAVIA; **Wool Surface Modification and Its Influence on Related Functional Properties**

**Gerhard Seyfriedsberger**, Wolfgang Kern; Polymer Competence Center Leoben GmbH, A-8700 Leoben, AUSTRIA; **Surface Modification of Polymers Towards Antimicrobial Properties**

## MODIFICATION OF FILMS AND COATINGS

**Goknur Bayram**, Guralp Ozkoc and Pinar Kurkcu; Department of Chemical Engineering, Middle East Technical University, 06531 Ankara, TURKEY; **Improvement of Adhesion Between Poly(tetrafluoroethylene) and Poly(ethylene terephthalate) Films**

**N. Inagaki**, Laboratory of Polymer Chemistry, Shizuoka University, 3-5-1 Johoku, Hamamatsu, 432-8561 JAPAN; **Surface Modification of Liquid Crystal Polyester, Vecstar, Films for Copper Metallization**

Daliana G. Abreu, Wagner Dasilva, Alan **Entenberg**, **Thomas Debies** and **Gerald A. Takacs**<sup>1</sup>; Department of Chemistry, Center for Materials Science and Engineering, Rochester Institute of Technology, Rochester, NY, 14623; **Surface Modification of Fluoropolymers: Relevance to Adhesion with Copper**

**Tadanori Koga**, J. L. Jerome, M. H. Rafailovich and J. C. Sokolov; Department of Materials Science & Engineering, State University of New York at Stony Brook, Stony Brook, NY 11794-2275; **Metalizable Polymer Thin Films in Supercritical Carbon Dioxide**

**Takeshi Tanaka**; Department of Electronics and Photonic Systems Engineering, Hiroshima Institute of Technology, Hiroshima 731-5193, JAPAN; **Surface Modification of Polymer Thin Films by PBII**

**Benoit Viallet**; INSA, 135 avenue de Ranguueil, 31077 TOULOUSE cedex 4, FRANCE; **Adhesion Improvement of Epoxy-Siloxane Resist on a BCB Layer: Application to Nanoimprint Lithography**

## PLASMA TREATMENT

**Saswati Datta**; P&G Beauty R&D, Room 1N106, Miami Valley Innovation Center, 11810 East Miami River Road, Cincinnati OH 45252; **Recent Advances and Applications of Plasma Surface Modification of Polymers**

**Jeremy Grace**, H. Kent Zhuang and Louis Gerenser, Eastman Kodak Company, Rochester, New York; **Importance of Process Conditions in Polymer Surface Modification: a Critical Assessment**

**Satoru Iwamori** and Yoshinori Yamada; Department of Human and Mechanical Systems Engineering, Kanazawa University, 2-40-20, Kodatsuno Kanazawa 920-8667, JAPAN; **Poly(tetrafluoroethylene) Thin films Deposited by PVD**

**E. T. Kang**; Dept. of Chemical Engineering, National University of Singapore, Kent Ridge, SINGAPORE 119260; **Plasma Graft Polymerization on Dense and Porous SiLK for Electroless Plating of Copper and Retardation of Copper Diffusion**

**Daniel Kaute**; PlasmaTreat North America Inc., 2810-1 Argentia Road, Mississauga, ON, L5N 8L2 CANADA; **Advances in the Understanding of Openair Plasma Technology and Latest Applications**

**U. Lommatzsch**, M. Noeske, T. Fladung, J. Degenhardt, T. Wuebben, S. Strudthoff, G. Ellinghorst, O.-D. Hennemann, Fraunhofer Institute for Manufacturing and Advanced Materials, D-28359 Bremen, GERMANY; **Pretreatment and Surface Modifications of Polymers by Atmospheric Pressure Plasma Jet Treatment**

## **SURFACE ANALYSIS METHODS**

**S. Markus**, R. Wilken, S. Dieckhoff, O.-D. Hennemann, Fraunhofer Institute for Manufacturing and Advanced Materials (IFAM), D-28359 Bremen, GERMANY; **Detection of Contaminations on Polymer Surfaces Using Laser Induced Breakdown Spectroscopy**

**Carosena Meola**; Laboratorio di Gasdinamica-DETEC, Università di Napoli "Federico II", Via Claudio, 21 80125 Napoli ITALY; **Characterization of Polymer Induced Modifications**

**Carosena Meola**; Laboratorio di Gasdinamica-DETEC, Università di Napoli "Federico II", Via Claudio, 21 80125 Napoli ITALY; **Infrared Thermography in Nondestructive Evaluation of Bonded Structures**

**Eckhard Schollmeyer**; Deutsches Textilforschungszentrum Nord-West e.V. (DTNW), D-47798 Krefeld, FRG; **Electrokinetic Investigations on Polymer Fibres**

**Marian Zenkiewicz**; Institute for Plastic Processing "Metalchem", ul. M. Skłodowskiej-Curie 55, 87-100 Torun, POLAND; **Experimental Comparison of the Owens - Wendt and Contact Angle Hysteresis Approaches for Determination of the Surface Free Energy of Corona Treated Polymeric Films**

## **SURFACE CHEMICAL TREATMENT**

**Takaomi Kobayashi**; Department of Chemistry, Nagaoka University of Technology, 1603-1 Kamitomioka, Nagaoka, Niigata, JAPAN 940-2188; **Polymer Surface Treated with Ozone by Using In-situ Instrumental Analyses**

**Renate Mix** and Joerg F. Friedrich; Bundesanstalt für Materialforschung und Prüfung (BAM), Unter den Eichen 87, D-12205 Berlin, GERMANY; **Wet-chemical Grafting of Spacers and Fluorophores onto Plasma-produced Monotype Functional Groups**

**Thomas Schuman** and Shelby Thames; University of Missouri-Rolla, Department of Chemistry and Materials Research Center, Rolla, MO 65409; **Role of Solvent in Producing Adhesion to Molded Polymer Surfaces**

**Sam Siau**, Alfons Vervaeet, Andre Van Calster and Daniël Baert; Department of ELIS, University Ghent, Sint-Pietersnieuwstraat 41, 9000 Gent, BELGIUM; **The Development of Epoxy Polymer Surface Roughness Due to Wet Chemical Treatments and its Relevance to Adhesion of Electrochemically Deposited Copper**

**Susanne Temmel**, Wolfgang Kern, Thomas Luxbacher; Polymer Competence Center Leoben GmbH, A-8700 Leoben, AUSTRIA; **Surface Modification of Polyethylene by Photosulfonation**

**Zhi-Kang Xu**, Zhen-Gang Wang, Xiao-Jun Huang; Institute of Polymer Science, Zhejiang University, Hangzhou 310027, P. R. CHINA; **Surface Modification of Polyacrylonitrile-Based Membranes by Chemical Reactions**

## **LASER/ULTRAVIOLET/PARTICLE RADIATION TREATMENT**

**Thomas Bahners**, Klaus Opwis, Eckhard Schollmeyer, Shang-Lin Gao and Edith Mäder; Deutsches Textilforschungszentrum Nord-West e. V., Adlerstr. 1, 47798 Krefeld, GERMANY; **Excimer UV Lamp Irradiation Induced Crosslinking on PET Surfaces**

**Casey Finstad**, John Madocks, Patrick Marcus, and Patrick Morse; Applied Process Technologies, Inc., 546 E 25th Street, Tucson, AZ 85713; **Surface Treatment for Improved Adhesion of Thin Films on Plastic Substrates Through Ion Bombardment by an Anode Layer Ion Source**

**P. Haque**, A.I. Mustafa, and Mubarak A. Khan; Applied Chemistry and Chemical Technology Department, University of Dhaka, Dhaka 1000, BANGLADESH; **Photografting of Chitosan Film with Ethylene Glycol and Ethylene Glycol Dimethacrylate Using Ultraviolet Radiation**

**Mubarak A. Khan**, Rashidul Alam and S.K Bhattacharia; Radiation and Polymer Chemistry Laboratory, Institute of Nuclear Science and Technology, Bangladesh Atomic Energy Commission. P.O. Box 3787, Dhaka, BANGLADESH; **Modification of Bio-blend of Chitosan and Water Soluble Polymers by Photocuring with Acrylic and Silane Monomer**

S. K. Bhattacharia and **Mubarak A. Khan**; Radiation and Polymer Chemistry laboratory, Nuclear Radiation Chemistry division, Institute of Nuclear Science and technology, Bangladesh Atomic Energy Commission, P.O Box 3787, Dhaka 1000, BANGLADESH; **Roll of Silane, Silicate and Sand on the Modification of the Wood Surface Properties by Photocuring**

**Dr. Y. Koval**; Physikalisches Institut III, der Universitaet Erlangen-Nurnberg, Erwin-Rommel Str. 1, 91058 Erlangen, GERMANY; **Polymethylmethacrylate Modification by Low Energy Ion Bombardment**

J. Zeng and **A. N. Netravali**; Dept. of Textiles and Apparel, Cornell University, Martha Van Rensselaer Hall, Room 289, Ithaca, NY 14853-4401; **Excimer Laser Treatment of Vectran Fibers and its Effect on Adhesion to Epoxy Resins**

**A. Priola** and R. Bongiovanni; Department of Materials Science and Chemical Engineering, Politecnico Di Torino, C.so Duca degli Abruzzi, 24 10129 Torino ITALY; **Design and Control of Surface Properties of UV-Curable Systems**

**E. Sancaktar**, J. Kim and D. Ahn; Department of Polymer Engineering, The University of Akron, Akron, OH44325-0301; **The Effects of Excimer Laser Ablation on Surface Morphology and Crystallinity of Uniaxially Stretched Poly(ethylene terephthalate) Films**

**V. Zaporajtchenko**, J. Zekonyte, U. Schuermann and F. Faupel; Faculty of Engineering, Chair for Multicomponent Materials, Christian-Albrechts University Kiel, Kaiserstrasse 2, 24143 Kiel, GERMANY; **Metallization of Polymer Surfaces after Ion Beam Treatment. Mechanism of Adhesion Improvement and Degradation**

## PRELIMINARY PROGRAM

### FIFTH INTERNATIONAL SYMPOSIUM ON SILANES AND OTHER COUPLING AGENTS

To be held June 22-24, 2005 NOVOTEL, Toronto Centre, Toronto, CANADA

This symposium continues the tradition set by the first symposium in this series: "Silanes and Other Coupling Agents" which was hosted in 1991 by the Dow Corning Corporation in honor of Dr. Edwin P. Plueddemann. As with its predecessors, this symposium will be concerned with the technological areas where the use of surface primers such as silanes is critical to the success of many technologies. The use of silanes as coupling agents for polyimide coatings and in glass fiber composites are just two applications where the use of silanes has been an enabling factor in the success of particular manufactured products. Quite surprisingly, silanes have also found a role in biotechnology as specific coupling agents for bonding polynucleotides to the so-called "gene chips".

This symposium is organized to bring together scientists, technologists and engineers interested in all aspects of coupling agent technology, to review and assess the current state of knowledge, to provide a forum for exchange and cross-fertilization of ideas and to define problem areas which need intensified efforts. The invited speakers have been selected so as to represent widely differing disciplines and interests, and they hail from academic, governmental and industrial research laboratories. This meeting is planned to be a truly international event both in geographic coverage as well as in spirit. The following is a partial list of papers to be presented at this symposium. Please note also that the address given may apply only to the presenting author.

### ADHESION IMPROVEMENT AND BOND DURABILITY

**Douglas H. Berry** and Apinan Namkanisorn;  
1) The Boeing Company, Seattle, WA;  
**Fracture Toughness of a Silane Coupled, Polystyrene-Aluminum Interface**

**Senthilkumar Chandrasekaran** and Wim J. van Ooij; Dept. of Chemical and Materials Engineering, University of Cincinnati, Cincinnati OH 45221-0012; **Electrodeposition of Bis-silanes for Pretreatment of Aluminum Alloys**

**Toru Fujii**; Dept. of Mech. Eng. & Systems, Doshisha University, Kyotanabe, 610-0394 JAPAN; **Effect of Moisture on Epoxy Metal Interfaces**

**Janis Matisons**; Nanomaterials Group, Flinders University, GPO Box 2100, Adelaide 5001, SOUTH AUSTRALIA; **Silanes on Glass Fibre Surfaces**

Guirong Pan and **Dale W. Schaefer**; Department of Chemical and Materials Engineering, University of Cincinnati, Cincinnati, OH 45221-0012; **Are Silane Films Water Barriers?**

Wim J. van Ooij, **Karthik Suryanarayanan** and Tammy Metroke; Chemical and Materials Engineering Department, University of Cincinnati, Cincinnati, OH 45221-0012; **Integral Epoxy Resin-silane Primer System for Hot-dip Galvanized Steel**

**Wim J. van Ooij**; Dept. of Materials Science and Engineering, University of Cincinnati, Cincinnati, OH 45221-0012; **Potential of Silane Coupling Agents to Replace Chromate Metal Pretreatments**

## COMPOSITE APPLICATIONS

**Karim Benzarti**; Laboratoire Central des Ponts et Chaussées, 58 Boulevard Lefebvre, 75732 Paris Cedex 15, FRANCE; **Influence of Glass Fiber Sizing on the Mechanical Behavior of Composite Materials: Investigation in the Low and High Strain Domains**

**J. Bouchet**, G. Rochat, B. Singh, Y. Leterrier, J.-A. E. Månson and P. Fayet; Laboratoire de Technologie des Composites et Polymères (LTC), Ecole Polytechnique Fédérale de Lausanne (EPFL), CH-1015, Lausanne, SWITZERLAND; **Influence of the Amino-organosilane/SiO<sub>x</sub> Interphase on the Barrier and Mechanical Performance of Nanocomposites**



**Bhanu P. S. Chauhan**; Department of Chemistry, City University of New York at the College of Staten Island, 2800 Victory Blvd., Staten Island, NY 10314; **Metal Nanoclusters Catalyzed Transformations of Silanes and Polysiloxanes**

**Dierk Knittel**, **Torsten Textor**, **Hans-Jürgen Buschmann** and Eckhard Schollmeyer; Deutsches Textilforschungszentrum Nord-West e.V. (DTNW), D-47798 Krefeld, GERMANY; **Surface Functionalisation of Textile Fibers with Reactive Silicon Compounds**

**Wilma K. Dierkes**; University of Twente, Chemical Technology, Rubbertechnology, P.O. Box 217, 7500 AE Enschede, THE NETHERLANDS; **Modeling and Practice of Ethanol-Devolatilization of Silica-Silane Rubber Compounds in an Internal Mixer**

**Eero Iiskola** and Satu Ek, Laboratory of Inorganic and Analytical Chemistry, Helsinki University of Technology, P.O.B. 6100, FIN-02015, Espoo, FINLAND; **Molecular Control of Interface Chemistry by Atomic Layer Deposition (ALD), Building Aminoalkoxysilane Monolayers on Porous Silica**

Sung-Hwan Choi and **Bi-min Zhang Newby**; Department of Chemical Engineering, The University of Akron, Akron, OH 44325-3906; **Dewetting Suppression of Polystyrene Thin Films on Surfaces Modified with Aminofunctional Organosilanes**

**C. Bellmann**<sup>1</sup>, **R. Plonka**<sup>1</sup>, **A. Caspari**<sup>1</sup>, **T. Luxbacher**<sup>2</sup>; Anton Paar GmbH, Anton-Paar-Straße 20, A-8054 Graz, AUSTRIA; **Characterization of the Interaction between Silanes and Solid Surfaces by the Streaming Potential Method**

## BIOTECHNOLOGY APPLICATIONS

**Alain Carré** and Valérie Lacarrière; Corning SAS, Fontainebleau Research Center, 7bis, avenue de Valvins, 77210 Avon, FRANCE; **Glass Substrates Modified with Organosilanes for Biological Applications**

**A. del Campo**, P. Stegmaier, E. Arzt; Max-Planck Institut für Metallforschung, Heisenbergstraße 3; 70569 Stuttgart, GERMANY; **Tailored Organosilanes for Functional Immobilisation of Biomolecules**

**Mark H. Lee**; Dept. of Bioengineering, Dept. of Materials Science & Engineering, University of Pennsylvania, Philadelphia, PA; **Self-Assembled Monolayers of Omega-Functional Alkylsilanes: A Platform for Understanding Cellular Adhesion at the Molecular Level**

**J. P. Matinlinna**, M. Özcan, L. V. J. Lassila and P. K. Vallittu; University of Turku, Institute of Dentistry, Dept. of Prosthetic Dentistry and Biomaterials Research, Lemminkaisenkatu 2, FI-20520 TURKU, FINLAND; **Silane Chemistry and its Applications in Dentistry**

**J. P. Matinlinna**, L. V. J. Lassila, M. Özcan and P. K. Vallittu; University of Turku, Institute of Dentistry, Dept. of Prosthetic Dentistry and Biomaterials Research, Lemminkaisenkatu 2, FI-20520 TURKU, FINLAND; **Some Rare Silane Coupling Agents and Their Novel Dental Applications**

**R. De Palma**, W. Laureyn, S. Peeters, K. Jans, K. Bonroy, W. Maes, S. Cappelle, G. Borghs, C. Van Hoof, and G. Maes; Interuniversity Microelectronics Center (IMEC), BELGIUM; **Silane Monolayers for Functional Nano-bio Interfaces**

**Henrik H. J. Persson**<sup>1</sup>, Stephen Kaplan, Mikki Lerner, Russell Kam, Ronald W. Davis and Nader Pourmand; Stanford Genome Technology Center, 855 California Ave., Palo Alto; **Plasma Enhanced Deposition of Silane Coupling Agents for Biological Applications**

**Mandla A. Tshabalala** and Li-Piin Sung; USDA Forest Service, Forest Products Laboratory, One Gifford Pinchot Drive, Madison, WI 53726-2398; **Sol-gel Deposition of Inorganic Alkoxides on Wood Surfaces**

## NOVEL APPLICATIONS

**Tanweer Ahsan**; Henkel Corporation, Olean, NY 14760 USA; **Silanes and Surface and Adhesion Properties of Mold Compounds in Semiconductor Packaging**

**Akshay Ashirgade**, Trilok Mugada and Wim J. van Ooij; Dept. of Chemical and Materials Engineering, University of Cincinnati, Cincinnati OH 45221-0012; **An Ultra-Flexible, Chromate-Free, Low-VOC, Silane-based Finishing and Coating System for Corrosion Protection of Aluminum Alloys**

**H.-J. Buschmann**, A. Wego, E. Schollmeyer, M. Felicetti, A. M. Richter and S. Jähnert; Deutsches Textilforschungszentrum Nord-West e.V. (DTNW), D-47798 Krefeld, GERMANY; **Incorporation of the Macrocyclic Ligand Cucurbit[6]uril into a Siloxane Matrix**

**C. Canal**, R. Molina, E. Bertrán, P. Erra; Surfactant Technology Department, IIQAB-CSIC, c/Jordi Girona 18-26, 08034 Barcelona, SPAIN; **Effect of the Post-application of Polysiloxanes on Plasma Treated Wool Fabrics**

**A. del Campo**, D. Boos, U. Jonas and H. W. Spiess; Max-Planck Institut für Polymerforschung, Mainz, GERMANY; **Photosensitive Silanes for Chemical Lithography**

**Rudolf Hager**; Wacker-Chemie GmbH, Burghausen, GERMANY; **The New High Speed Technology: Alpha-Silanes**

Renaud Briard, **Caroline Heitz** and Etienne Barthel; Surface du Verre et Interfaces, Unité Mixte de Recherche CNRS/Saint-Gobain, UMR 125, 39 Quai Lucien Lefranc, F-93303 Aubervilliers cedex, FRANCE; **Glass Strengthening by Organosilanes Water-based Coating**

**E. T. Kang**; Department of Chemical Engineering, National University of Singapore, 10 Kent Ridge Crescent, Singapore 119260, SINGAPORE; **Functional Polymer-Si and Polymer-SiO<sub>2</sub> Hybrids via Surface-Initiated Living Radical Polymerization**

**RamaKrishna Nookala** and Wim J van Ooij; Department of Chemical and Materials Engineering, University of Cincinnati, Cincinnati, OH 45221-0012; **Performance of Silanes in Protecting Metals from Corrosion: Effect of Substrate Cleaning**

**Eric R. Pohl** and Antonio Chaves; GE OSI Specialties, 777 Old Saw Mill River Rd., Tarrytown, NY 10591-6728; **Glycoxysilanes and Their Use to Reduce Volatile Organic Compound Emissions**

**Anuj Seth**, Lin Yang, and Wim J. van Ooij; Department of Chemical and Materials Engineering, University of Cincinnati, Cincinnati OH 45221-0012; **A Novel, Low-VOC, Chromate-free, One-Step, Silane-Based Primer System for Corrosion Protection**

Torsten Textor, Klaus Opwis, Thomas Bahners and **Eckhard Schollmeyer**; Deutsches Textilforschungszentrum Nord-West e.V. (DTNW), D-47798 Krefeld, GERMANY; **Surface Photografting of Unsaturated Alkoxysilanes onto Polyolefins with Excimer-UV-lamps**

**Steve Shaw**; Room 19, Building 231, Defence Science and Technology Laboratory, Porton Down, Salisbury Wiltshire SP4 0JQ, UK; **Optimised Silane Treatments for Aluminium Alloys**

**Chetan Shivane**, Naveen BV Simhadri, Wim J. van Ooij; Dept. of Materials Science and Engineering, University of Cincinnati, Cincinnati, OH 45221-0012; **Improved Water-based Silane Pretreatment for HDG Substrates**

**B. Viallet**, J. P. Peyrade, L. Ressler, C. Martin, J. Grisolia; LNMO, Département de Génie Physique, INSA - CNRS, 135 Avenue de Rangueil, 31077 Toulouse Cedex 4, FRANCE; **Local Chemical Vapor Deposition of Silane for Combining Top down And Bottom up Approaches**

**Lin Yang**, Anuj Seth, Naveen Simhadri and Wim J. van Ooij; Department of Chemical and Materials Engineering, University of Cincinnati, Cincinnati, OH-45221; **Novel Corrosion Inhibitors for Improved Silane Systems**

## INTERFACE STUDIES

**Ali Dhinojwala**; Department of Polymer Science, The University of Akron, Akron, OH 44325; **Infrared-Visible Sum Frequency Generation Spectroscopy to Probe Hidden Polymer Interfaces**

**F. R. Jones**, J .L. Thomason and X. M. Liu; Department of Engineering Materials, University of Sheffield, Sheffield, S1 3JD, UK; **The Differential Adsorption of Silanes from Solution onto Model E-Glass Surfaces Using High Resolution XPS**



**X. M. Liu**, J. L. Thomason and F. R. Jones;  
Department of Engineering Materials,  
University of Sheffield, Sheffield, S1 3JD, UK;  
**The Interaction of Amino and Glycidyl  
Silanes with E-glass Surfaces**

**Anthony A. Parker** and Jane Hollenberg; A. A.  
Parker Consulting & Product Development;  
Newtown, PA; **Comparative Studies of  
Hydrophobic Surface Treatments for TiO<sub>2</sub>:  
n-Octylphosphonic Acid vs.  
n-Octyltriethoxysilane**

# REGISTRATION INFORMATION

## DATES:

**JUNE 20-22, 2005: FIFTH INTERNATIONAL SYMPOSIUM ON POLYMER SURFACE MODIFICATION**

**JUNE 22-24, 2005: FIFTH INTERNATIONAL SYMPOSIUM ON SILANES AND OTHER COUPLING AGENTS**

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Speaker/student \$395 each; regular attendee \$595 each. A 20% discount applies if you are attending both symposia. An additional 10% discount applies if more than 1 person is participating from the same organization.

**HOTEL:** Please make room reservations directly with the NOVOTEL Hotel no later than May 8, 2005 in order to secure the special conference rate. After this date the hotel will accept reservations on a space available basis and they cannot guarantee that the special conference rate of \$169 CAD (single or double) per day will apply. Make your reservations early and be sure to mention that you are attending one of the MST symposia in order to receive the reduced conference hotel rate.

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Associated with these symposia MST gives a short course on adhesion measurement methods. Since nearly all of the MST symposia have some relation to adhesion phenomena, the ability to quantify the adhesion of one material layer to another is clearly one of the unifying themes. This course is designed to mesh with the topical symposia by presenting an overview of the most useful adhesion measurement techniques which are being used to evaluate the **PRACTICAL ADHESION** of coatings. Emphasis will be given to methods which can be carried out in a manufacturing environment as well as in the lab and which give results that are directly relevant to the durability and performance of the coatings. The effects of material elastic properties and residual stress are considered as well as other external influences which affect coating adhesion.

**Audience:** Scientists and professional staff in R&D, manufacturing, processing, quality control/reliability involved with adhesion aspects of coatings or laminate structures.

**Level:** Intermediate

**Prerequisites:** General background in chemistry, physics or materials science.

**Duration:** 1 day

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## How You Will Benefit From This Course:

**Understand advantages** and disadvantages of a range of adhesion measurement techniques.

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**CANCELLATIONS:** Registration fees are refundable, subject to a 15% service charge, if cancellation is made by May 8, 2005. **NO refunds** will be given after that date. All cancellations must be in writing. Substitutions from the same organization may be made at any time without penalty. MST Conferences reserves the right to cancel any of the symposia or the short course if it deems this necessary and will, in such event, make a full refund of the registration fee. No liability is assumed by MST Conferences for changes in program content.

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