Electrostatics Group Newsletter

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Shock horror probe – the world of a static electricity consultant

Mention static electricity and most people think of dusty physics school books with odd experiments – the Van de Graff generator, long sparks and hair standing on end….. rubbing things with cats fur…gold leaf electroscope and electrophorus…..I ask you, what relevance has it to industry and every day life in the real world?

A great deal, actually. Electrical charges are separated whenever two materials in contact are separated – and so charges are being separated all the time in many different situations around us. We probably didn't notice this much until we started using highly insulating materials, such as plastics and rubber, in our homes, offices and workplaces, preventing charges from dissipating harmlessly and encouraging them to build up as electrostatic voltages. Who hasn't experienced a static electric shock? Nowadays we put insulators on our feet and lay highly insulating floor materials, use man-made fiber clothes and furnishings. We put plastic wheels on carts and make our machines out of engineering plastics.

A shock often shows we had charged to about 4kV or more before we released that charge in an electrostatic discharge (ESD). In the electronics industry most semiconductor devices are susceptible to ESD damage. A human body charged to 100 V or less can destroy some sensitive components. Circuit boards have to be handled and assembled in ESD Protected Areas where electrostatic fields and voltages are kept to a low level. A voltage susceptible device may suffer breakdown of a thin insulating layer (e.g. gate oxide of a MOS transistor) – it takes only a small amount of charge to charge up the small gate capacitance (a few picoFarads) to the breakdown voltage (a few volts). An energy susceptible device may fail by a high ESD current of a few amps passing through a micron size device junction or interconnect metallization, bringing it to melting point. Outside the EPA susceptible circuit boards and devices must be protected against electrostatic fields and ESD currents by shielding packaging. A whole industry has grown up supplying ESD protective equipment and packaging to the electronics industry – for my part I research ESD topics, provide consultancy services and advise on best practice, run ESD training seminars and help write standards such as IEC 61340-5-1 to provide guidance to industry.

Small consultancy jobs can be extremely varied. Often the solutions are simple in principle, and in practice with a little knowledge the situation could have been avoided, but remedial action may be difficult or expensive. In one case, the client reported drivers in their car park experienced severe shocks when pulling parking tickets from a dispenser. A site visit showed that a new epoxy floor covering had been fitted up a long ramp that brought cars to the barrier –and all the charge stored on the car (say 800 pF capacitance, charged to several kV?) would be discharged through the driver's arm. The cure – fit conductive floor next to the ticket barrier so that the car could dissipate its charge through its tyres.

An embassy in a northern climate complained that the ambassador was getting shocks when she ascended stairs and touched her office doorknob. The stairs were made of glass, a good insulator and at the other end of the triboelectric series from most shoe sole materials. Ideally, I would recommend not fitting a highly insulating glass floor. The remedial action – a surface treatment – is probably unreliable and requires regular refreshment. Similarly, in a new prestige UK site severe shocks were experienced on the stair wells. The architect had specified beautiful but highly insulating tread tiles that charged a typical person to over 5 kV within a few steps. A well earthed stainless steel banister ensured that they would get a good shock. It is difficult to specify low cost and reliable remedial action in the face of such built-in electrostatic problems.

In a high street retail site staff complained that "the lift was giving (them) shocks". It had a metal fascia that had been shown to be well earthed. The Saturday lad had taken to wearing rubber washing up gloves, he suffered so much. The lad's duties included loading a large mobile metal rack (on insulating wheels of course) with highly charged garments in polythene covers from a lorry, and then wheeling them along a highly insulating carpet to the lift, both lad and trolley reaching over 8 kV.

In the USA, many petrol fuelling facilities have latching nozzles that allow the user to go away while the vehicle is filling. Many people return to wait in their car when the weather is cold. When they get out, their body voltage may rise to around 10 kV. When they pick up the fuelling nozzle to remove it from the tank aperture, the resulting spark can ignite the emerging petrol vapour causing fire and injury.

Many fine dusts can be ignited by electrostatic sparks. Factories have been destroyed, and avoiding fires and explosions is a real issue in chemical industries. With solvents and flammable vapours the risk of ignition is even greater. It may only take 0.2 mJ energy to ignite a vapour - the equivalent of about 10 kV on a drinks can, or a few kV on a charged person. Vapours can also be ignited by brush discharges from charged insulating surfaces. Insulating solvents charge to high levels when running through pipes, splashing or during filtering. Conductive objects (including people!) must reliably earthed, and plastic surfaces are typically limited to less than 100 cm^2 area. Insulating powders charge highly during transport. The charge builds up when they are deposited in a silo, creating a highly charged pile with potentially flammable fine dust cloud above. The CENELEC TR50404 standard has been written to give guidance covering a wide range of industrial circumstances.

Static electricity can also be used for our benefit. Electrostatic separation can be used to separate some

materials that are difficult to separate by other means. A mixture of plastics chips from recycled wasted can be separated on the basis of their triboelectric charging properties. An insulating material such as rubber or plastic can be separated from a conductor such as wire fragments, paper or card.

The architect with me on the car park visit, faced with several kV measured on a car, commented incredulously "How could we have predicted this?". Actually, even a little knowledge of static electricity applied during the design stage would avoid many electrostatic problems. Unfortunately it is rarely considered until problems show, by which time it is too late. Far from being irrelevant, static electricity is highly important in a very wide range of modern home and industrial environments and processes and is an everyday fact of modern life.

Dr Jeremy Smallwood,
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Conference Report: IEJ-ESA Joint Symposium on Electrostatics

7-10 November 2004 Sanjo Conference Hall, The University of Tokyo, Tokyo, Japan

The 6th joint symposium of the Institute of Electrostatics Japan (IEJ) and Electrostatic Society of America (ESA), first held in 1994, returned to the University of Tokyo last year with a Special Symposium on Atmospheric Pressure Plasma Applications.

With the support of the Royal Academy of Engineering I was able to attend this conference and present some research from a recent project. This being my first visit to Japan, I was impressed by the hospitality and the enthusiasm of our Japanese hosts for the subject. It is always stimulating to be amongst like-minded scientists, especially when the usual tone of enquiry back home is 'what future for electrostatics?'. Well, from the diversity of research presented on this occasion you would have to conclude that electrostatics continues to deliver industrial innovations in its traditional areas, but is also generating new tools for manipulating biological materials and environmental protection. The scope of the conference covered all aspects of electrostatics and its applications, in diverse topics such as environmental protection, manufacturing applications, hazards and biological manipulation.

The conference benefited from a wide ranging international audience and speakers from the USA, Canada, England, Korea, France, Germany and Hungary, as well as from Japan. The conference was run under the familiar session titles of Particles, Applications, Biological, Surface Charge, Charge Behaviour, Calculation, Charging and Discharging, Safety and Other Topics. In the special symposium on atmospheric pressure plasma applications, sessions were divided into Air Cleaning, Flue Gas Process and Other Topic sessions.

The opening talk of the conference was given by Peter Castle from the University of Western Ontario, Canada, on electrostatic levitation of fine particles. This set the scene on a day of talks dominated by industrial applications. A most entertaining presentation was delivered by Gerard Touchard (Laboratoire d'Etudes Aerodynamiques, France) on flow electrification with respect to the phenomenon in transformers. A visual dimension to the theoretical aspects of the subject was achieved to great effect. Experimental analysis of the phenomenon in high power transformers, including the influence of flow geometry and the press board composition, were used to demonstrate that while the mechanical parameters are now rather clearly understood, the physiochemical process at the interface is still very difficult to analyse.

The 'Biological' session saw presentations on new methods for manipulating chromosomal DNA strands using micro-devices, and an analytical model for DEP liquid actuation in viscous medium. The proposed micro-device of Terao, Kabata and Washizu (University of Tokyo and Kyoto University) positions cells in individual pockets of an array, such that the DNA strands can be drawn out of ruptured cells by electroosmotic flow, stretched and anchored onto micro pillars. The DNA strands allow free interaction with probe molecules as they are suspended above the surface, and remain intact as excessive hydrodynamic stresses are avoided. Washizu's group from Tokyo have also developed an analytical model for DEP liquid actuation in a viscous medium. The viscous force exerted on the side and at the front of the liquid finger is taken into account. Experimental verification showed good agreement with the calculated values. This model should provide design rules for DEP liquid transport and dispensing on-chip micro-chemical systems.

In the special symposium on Atmospheric Pressure Plasma Applications a most interesting presentation was given by Dr Louis Rosocha (Los Alamos National Laboratory, USA) on the use of non-thermal plasmas to enhance combustion processes. Passing Fuel gases such as propane through a plasma discharge splits the molecules into shorter units, making the combustion process more efficient. Efficiency improvements are shown by increases in water and carbon dioxide production, and a reduction in unburnt hydrocarbon in the exhaust gases. Energy density analysis shows the total energy output of the plasma assisted technique to be around 40% higher. There were also a significant number of papers on plasma-catalyst systems for environmental protection. Methods differed from institute to institute, where most used a dielectric-barrier type discharge, a parallel type streamer corona discharge was also used. In many aspects continued work is needed and further improvements in will be obtained.

In addition to the scientific part of the conference, a number of social activities were also enjoyed. A welcome dinner was greatly enjoyed by the western guests on the first evening, and a splendid buffet-style conference dinner on the final evening.

Lindsey Gaunt,
Bioelectrostatic Research Group, School of Electronics & Computer Science, University of Southampton,

Notices and events

Annual General Meeting

The annual general meeting of the Electrostatics Group will be held on the 19th May 2005 at the Institute of Physics, 76 Portland Place, London. It will take place at lunchtime during a one-day meeting on Electrostatics in the Life Sciences. The committee would like to invite as many members to attend as possible.
If members have any matters they would like to be raised at the meeting can they please contact the Group Secretary Nicolas Green at the email address given below.

One day meeting

Electric fields and discharges for microbiology and health care applications

To be held at the Institute of Physics, 76 Portland Place, London on Thursday May 19th 2005.

Electric fields and discharges have long been known to influence many aspects of cell and micro-organism physiology, metabolism and viability. Today, multidisciplinary research is widely undertaken by scientists from many disciplines seeking to manipulate cells, understand their responses to fields and discharges, and to disinfect the air, surfaces, food stuffs and fluids from micro-organisms. The Electrostatics Group of the Institute of Physics is hosting a meeting to bring together interested parties from academia, industry and health care to communicate recent progress in this field and discuss its implications to future applications. The meeting will include discussion of research into pulsed electric fields for both sterilisation applications and cell manipulation, and the use of ionisation for sterilisation and infection control.

Please contact Dr Lindsey Gaunt for further information at the University of Southampton on 023 8059 5163 or by e-mail; lfw1@soton.ac.uk

Applications are currently being accepted for oral and poster presentations

A number of bursaries will be available to assist PhD students and new post docs in attending, sponsored by Children with Leukaemia and the Electrostatics Group of the Institute of Physics.

IoP hosts IEC TC101 Electrostatics

This year in April the International Electrotechnical Commission (IEC) standards Technical Committee TC101 (Electrostatics) is holding its General Meeting hosted by the UK National Committee at BSI, London. The week-long meeting is an opportunity for TC101 experts to get together and discuss projects such as the next version of IEC 61340-5-1 (Protection of electronic devices from electrostatic phenomena in electronics manufacture) and a variety of electrostatic test methods. These become IEC standards for worldwide use by industry. Several IoP Electrostatics Group members are experts working in IEC TC101, or in the participating National Committees.

It is traditional for the host country to give a dinner and social event to the TC101 delegates. On this occasion they will be treated to a visit to NPL, including dinner sponsored by the Institute of Physics. IoP Electrostatics Group Ex - Chairman Dr Jeremy Smallwood is current TC101 Chairman and a participant in the host BSI committee. “We (BSI committee GEL101) were looking round for ideas for an event and potential sponsors, and I decided to approach IoP.”, he said. “ I was very pleased to find they were supportive, suggesting NPL as a venue and offering to cover the cost of the dinner. They were also able to contact NPL and arrange the event in principle on our behalf. The NPL venue will be especially interesting for the delegates with their history of measurements and standards development”

Message from the editors (current and new)

If you have any news or articles that you would like to appear in the newsletter, please contact the following people:

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