Materials Engineering e-Newsletter

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The IMEA Sydney Branch Materials Engineering e-Newsletter is a monthly electronic news service for members of IMEA. It contains information on Sydney Branch activities and items of interest to its members.

APRIL 2004

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FROM THE PRESIDENT'S DESK

There were two extremely interesting talks given during the month. Both have the potential to cause a major rethink in manufacturing.

Peter Wells, of Weir Warman, gave the first talk on lean manufacturing. In my opinion, lean manufacturing has the potential to become in this decade what quality became during the nineties. It is a way of looking at and transforming the complete business process. It is clearly the key to improving productivity.

It works to eliminate waste. In doing this it creates the environment where customer demand has production being *pulled* through the process, as opposed to production being *pushed* through the process. The promise of lean manufacturing is a 25 to 50% improvement in inventory for work in progress and finished goods, as well as lead-time, floor space ultisation and rework.

If manufacturing and indeed if most economic activity is to survive and prosper, serious consideration needs to be given to lean thinking.

A brief summary of the talk is enclosed in this newsletter.

Brian Wood, from Metacoustics, in his 2004 Adrian Ashton Lecture gave the second talk. Brian's talk was on the *Structural integrity and remnant life evaluation of manufactured structures using acoustic stethoscope*. This centered on being able to predict the real time structural integrity and remnant safe operating working life of structures by using acoustic emission techniques.

The level of accuracy using this technique has the potential of extending the working life of plants and avoiding catastrophic failure. In a number of case studies Brian showed that an accurate predication could be made years in advance of when a structure is likely to fail.

Again a brief summary of Brian's talk is given in this newsletter.

On a different topic altogether Sydney Branch has a number of vacancies on its Council. If you would like to become a member of Council and become more active in your organization we would like very much to hear from you. You can contact any of the Branch Councillors listed in the Directory in this Newsletter.

Warren Geering
Sydney Branch President

WHY NOT JOIN IMEA?

If you are not an IMEA Member but enjoy the e-Newsletter why not join IMEA and receive the other services, including Materials Australia, that our Members enjoy?

A Membership Information Package that details the benefits of membership is available from
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APRIL PLANT VISIT

HYDROLOGICAL SERVICES

When: Tuesday 20 April 2004

Where: Hydrological Services
48-50 Scrivener St, Liverpool
Scrivener St is a left turn off the Hume Highway just before the Warwick Farm rail overpass, heading south.

Time: 2pm Sharp

Dress: Please wear trousers and covered footwear.

Hydrological Services is a specialized designer and manufacturer of hydrological scientific instruments including water flow metering products, water level recorders, tipping bucket rain gauges and data loggers as well as a new flood warning system. The company also provides calibration services to the highest world quality standards. The company is innovative, developing and manufacturing its own testing equipment, including electronics, and has calibration equipment including a 64m High Velocity Tow tank and testing for temperate shock and humidity.

Numbers are limited
BOOKING IS ESSENTIAL

To register, contact Robyn Faber
Phone 02 98905744 or 0401710600
Email robyn.faber@business.nsw.gov.au

NO LATER THAN FRIDAY 16 APRIL 2004

REPORT – 22ND ADRIAN ASHTON LECTURE

In presenting the 22nd Adrian Ashton Lecture on 17th March, Brian Wood, Managing Director of Metacoustics Pty Ltd, took as his theme *the structural integrity and remnant life evaluation of manufactured structures using the acoustic stethoscope*.

He pointed out that when a material or object is placed under stress, any defect which is activated by that stress will release energy and so act as a source of elastic waves. The resultant surface wave which propagates along an external boundary can be detected by an appropriate transducer placed on, or very close to, the material surface.

The transducer produces an electrical impulse which may be analysed in either the time domain or the frequency domain to provide a framework to determine much of the information contained in a signal. A desirable end-point of all the processing is to present the data in ways which will readily provide a real time indication of Structural Integrity.

The Analysis Techniques, which are based on laboratory research on the various materials used in such structures as mine equipment, pipelines, beam structures, tanks, pressure vessels, bridges and dams, combine the physical properties of these materials and the waveform analysis of data recorded during field tests to derive the Structural Integrity Index.

The need to validate data and their interpretation has never been so important. The correct detection of Acoustic Emission data and the simultaneous analysis of that data using these techniques are necessary to ensure the safe and efficient use of industrial plants and structures.

Sydney Branch President, Warren Geering, thanked Brian for presenting the Adrian Ashton Lecture in such an informative and interesting way, and presented him with a commemorative pewter tankard.

Brian Wood - 2004 Adrian Ashton Lecturer is on the left and Dr Ron Beckett the 2003 Adrian Ashton Lecturer is on the right

Reported by Kerry Weight

NATIONAL DIRECTORY FOR RADIATION PROTECTION

The Australian Radiation and Protection and Nuclear Safety Agency (ARPANSA) is inviting submissions on the Draft *National Directory for Radiation Protection, Edition 1.0*.

The aim of the Directory is to provide nationally uniform requirements for the protection of people and the environment against exposure or potential exposure to ionising and non-ionising radiation and for the safety of radiation sources, including provision for the national adoption of codes and standards.

The draft edition and other information can be downloaded from the ARPANSA website (http://arpansa.gov.au/for_comm.htm), or a free copy of the draft can be obtained by phoning (03) 9433 2207.

The closing date for submissions is 2 April 2004, which will be before you read this notice; nevertheless, ARPANSA will welcome enquires and input.

KILLEY'S KORNER

OCCUPATIONAL HEALTH AND SAFETY

It's amazing just how far-reaching the OH&S legislation is and how great its potential to affect our lives.

Having just been involved in its implementation in a community based Neighbourhood Centre I am now more aware of what can happen in industry.

In some cases, as for those working at considerable heights, the perils and remedy are obvious and there is little sympathy for those who flout the rules and cause injury or death to the untrained or unwary. In other cases the problem is not so apparent but the outcome can be spectacular.

For instance, the modern automotive ring gear is oil quenched in a restraining die press to ensure its dimensional accuracy for current applications. Up till now this has meant normal removal from a heat treatment furnace by a skilled operator and accurate location of the gear for the quench. Possible damage to the gear and back injury to the operator have always been concerns.

These have now been addressed in the new installation now undergoing commissioning at the Fairfield, NSW, factory of Spicer Australia where this task has been taken over by robots and it is anticipated that there will be an improvement in the finished product quality while back injuries will disappear. Should be quite a sight when we in IMEA have the chance to view the operation.

BUYING BACK THE TOWN

We are all accustomed, for better or for worse, for Australian icons such as Vegemite and Arnotts being bought out by American interests. This was made easy by the low exchange rate for the $A over a number of years. But now the worm has turned and with an exchange rate approaching 80 cents it is quite feasible for Australian enterprises to expand overseas. Hence the announcement that BlueScope Steel Limited is about to buy out the USA based construction engineer Butler Manufacturing is good news.

Butler is the largest producer of pre-engineered metal buildings in the US and China with around 18% of the Chinese market. In addition BlueScope Steel Limited has announced that it will build a new steel mill at Suzhou, west of Shanghai at a cost of $280 million. The new plant will have metallic coating capacity of 250,000 tonnes with a paint line capacity of 150,000 tonnes. Like the Butler acquisition the new plant is aimed at the building and construction markets.

ELECTRIC POWER

There seems to be no doubt that we have a crisis of sorts on our hands when we look at our current and future electricity needs. On the one hand we are heavily dependent on coal-fired electricity generators which spew out millions of tonnes of greenhouse gases. In their turn, these lead to global warming, unpredictable weather patterns (famine in Africa, storms in New Zealand, tornadoes and storms in USA, heat waves in Australia and so on) with continued melting of the ice caps and shrinking of the ski fields.

On the other hand we have a plan to produce just 2% of energy needs by renewable technology such as solar and wind power by the year 2010. Hardly a promising approach to the problems affecting our planet.

There is a need, I believe, for us to either drastically reduce our energy consumption - which is highly unlikely - or else find another method of power generation. And unless we want to continue to live in a world plagued by 'natural' disasters, we need to do this very quickly.

So I will be listening very closely to the next 'Ockham's Razor' program on the ABC when Dr. Kay will be explaining why we need nuclear energy. Hardly a popular topic these days, but realistically, is there any alternative?

MAGIC EYES

As lenses go, this one is very strange. It consists of a circular slab of transparent rubber a little smaller than a jam-jar lid, and is held in an aluminium frame with a wire hanging from it. Light seems to pass through it in just the same way as through any other transparent material and the view through the lens is nothing special. It is hard to believe that something so modest-looking has the potential to change optics for ever.

But switch the power on and something happens. Although the slab of rubber stays the same, the view through it changes dramatically. Such lenses could upset everything from high-powered telescopes and military guidance systems to cheap disposable cameras.

WHY THERE'S ALWAYS ROOM FOR A FEW EXTRA CHOCS

A jar of M&M chocolate treats turns out to have a peculiar mathematical property. The ellipsoid-shaped sweets pack far more densely into the jar than spherical objects like marbles.
It has long been known, at least to mathematicians, that if you put marbles into a jar and gently shake them to pack in as many as possible, the marbles will occupy no more than about 64 per cent of the jar's volume. This is called random close packing.

But when physicist Salvatore Torquato of Princeton University in New Jersey and his colleagues did this with M&Ms, they found the randomly packed sweets approached a packing density of nearly 71 per cent. Using computer simulations, they found that by tweaking the dimensions of the ellipsoid, the packing density could be increased to nearly 74 per cent (Science, vol 303, p 990). In random packing, the greatest packing density is obtained when the contents are mechanically stable. Ellipsoids, it turns out, become stable when they are in contact with many more neighbours than happens with spheres.

A MULTIFACETED MATERIALS ENGINEER

The following report appeared in the 21 March 2004 issue of the Sydney Morning Herald. It highlights the many skills of Saul Griffith, a graduate of the School of Materials Science and Engineering, UNSW, and a former Student Member of IMEA.

While a student at UNSW, Saul was a member of the New South Wales Golf Club at La Perouse and played off a handicap of 3. The year he played in the IMEA Golf Day, he had a par round of 72 and was runner - up on handicap.

***S**aul Griffith credits his parents for never scolding him when, as a child, he dismantled his toys to see how they worked.*
"Any Christmas present was a pile of parts by the end of Christmas Day", the Massachusetts Institute of Technology doctoral candidate said yesterday.

***Y**esterday Mr Griffith, 30, was awarded a $38,000 prize for inventing a machine the size of a desk-top printer that can turn out spectacle lenses for about $1 each. He hopes it will allow people in the Third World to afford the glasses they need to read.*

***S**peaking from Boston, he said he began working on the idea after showing Kenya's education minister one of his projects – an "electronic book" the size of a sheet of paper that could store as much information as a library.*

***B**ut the minister said about a quarter of Kenyans cannot read because they need glasses.*

***M**r Griffith committed himself to finding a solution.*
"I built a lot of prototypes of crazy ideas that didn't work."

***H**e finally came up with what looks like a set of ski goggles with a built-in computer chip.*

As the patient wears the goggles, its lenses adjust themselves until the person can see clearly. The information is then downloaded into the printer-like machine that uses thin film, resembling plastic wrap, to make a lens mould that is then injected with hard plastic.
*"**I**t produces a lens in five or 10 minutes," he said. "You can make a pair for under $1." He estimated the machines could be made for a total of less than $2500. The work won him the MIT-Lemelson Student Prize for inventiveness.*

*"**I** graduate from MIT in a month or two," he said, adding, "I've started a little engineering firm. We may end up making the devices."*

He admitted he only narrowly decided against a career as a professional golfer, having played for his school and state as a teenager.

His other interests include running Howtoons, a website showing children how to make inventions from ordinary household objects, and cycling.

***B**ut not everyone has been awed by Mr Griffith. During the 1990s he participated in Sydney traffic-jamming Critical Mass cyclists' protests. "I remember doing a radio interview with Alan Jones. He told me I should be put in jail."*

***Y**esterday his father, Ross, said Saul "always had the idea that if he could pull it apart, he could make it better. He was always a tinkerer. His bike was never standard."*

Reported by Bob Stack

The Confusion Surrounding Nanotechnology

Don Maclurcan, Mike Ford and Mike Cortie
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According to many, nanotechnology will be the next technological revolution, dramatically changing all areas of society over the coming 10 or so years. The level of investment in North America, Europe and East Asia in the last four years indicates confidence in this vision. But to what kind of technology are we referring? Writing has often blurred the important boundary separating nano-science and nano-technology, creating an undesirable level of public and private sector confusion.

Science at the nanoscale (1-100 nanometres) is not new. Scientists have been dealing with reactions and processes at this scale since Dalton's 1803 claim that matter is made of indivisible particles called atoms. After all, Faraday is credited as the father of gold colloids. Nanotechnology *is* new because it represents an unprecedented concentration of scientific endeavour at the nanoscale, resulting in a cross-disciplinary assault on understanding how things behave in this realm and how to utilise such information in a practical manner. Novel efforts to build functional objects from the 'bottom-up', (i.e. assembling structures from their base components, rather than the traditional method of miniaturisation and carving objects down to size), are facilitated by emerging tools, techniques and funding. Nanotechnology applies new and existing knowledge to exploit size-dependent phenomena, such as enhanced conductivity, reactivity and binding properties exhibited in nanoscale matter (think about how a Teflon pan is non-stick). Considering a red blood cell is in the order of 6-8 thousand nanometres [1], we are dealing with an extremely small scale.

Over recent years the media has flourished with futuristic dreaming. You may have seen 'nano reconstructors' in *Minority Report*, read Crichton's *Prey*, or heard 'robots in the bloodstream' mentioned at the dinner table. The latter ideas stem from U.S. scientist, Eric Drexler's, proposal that atoms and molecules could act as self-assembling machinery, performing production tasks at the nanoscale. Originally known as nanotechnology but now 'molecular manufacturing', this science remains purely theoretical. Feasibility, more than theoretical validity, is causing divide amongst the scientific community, as many cannot foresee our capability to create tools for the application of the proposed concepts. Yet, there are U.S. companies, such as Zyvex, who's underlying goal is to manufacture molecular machines, despite recognition in 2000 that 10 years would be an optimistic time frame for such applications [2]. Biomolecular motors powered by ATPase [3] and the ability to write 'I.B.M' with 35 xenon atoms [4], are striking examples of nanoscience. However, a technology, by definition, must deliver practical outcomes.

Alternatively, an entire industry is developing independent of Drexler's visions, with an increasing number of products entering the market, mostly unbeknownst to the general public. The infiltration will continue to be subtle, because most developments will come through familiar industries such as materials, biotechnology and ICT. It would seem this revolution 'will not be televised'. Australian household applications utilising nanotechnology, such as clear sunscreens (Advanced Powder Technologies), supercapacitors for laptops and phones (Cap – XX) and smart paints (Dulux/Orica), have eased into our lives without hype or any considerable concern.

Australian involvement is occurring at all stages of the production line, exemplified by Micronisers producing a film coating to reduce UV absorption through glass, Bottle Magic then applying the film to wine bottles, and Southcorp marketing the wine. Building on the 1997 claim that Australian enterprise, was the first to produce a 'nanomachine' [5], companies such as Advanced Nano Technologies, pSivida, Starpharma and Cap – XX have established reputations as global leaders in their respective areas.

With a global market value predicted to exceed $U.S. 1 trillion by 2011 [6], numerous Australian patents and signs of research in 70 countries [7], nanotechnology *will* be a revolution, but not of the overt nature. Nanotechnology offers a sustained life-cycle for a number of reasons. Firstly, atoms are the base unit and most efficient length scale for manufacturing [8]. 'Nano' is the most appropriate scale to tackle problems such as disease [9]. And the convergence of the physical sciences at this scale facilitates potential for extensive collaboration and parallel gains.

With limited time and resources, persistent public hype creates a bubble that should give dot-com investors a shiver, whilst stealing focus from pressing legal, ethical, environmental and health discussions of emerging applications. Nanotechnology is exciting enough without delving into science fiction. One does not need promote U.S. nanotechnology defence hopes that soldiers will be able to jump the height of buildings, when self-cleaning windows, and sensors able to detect the existence of a teaspoon of sugar in Sydney harbour [10], are a reality. The public misconception that all nanotechnology is high tech [11] and based on the concept of molecular manufacturing, hinders rational domestic and international discussions. Although

not a panacea, nanotechnology has the potential to revolutionise global production, strengthen economies and assist critical local problems. Yet it is an enabling technology, synthesising and progressing efforts in existing industries, rather than a futuristic, speculative industry based on molecular manufacturing.

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LEAN MANUFACTURING

The Sydney Division of Engineers Australia held a technical meeting in which a talk was given by Peter Wells from Weir Warman on lean manufacturing.

The concept of lean manufacturing is very likely to become during this decade what quality was during the nineties.

The fundamental objective of lean manufacturing is to provide perfect value to the customer by total elimination of waste. This occurs during all stages of a product from design through to recycling at the end of life.

The promise of lean manufacturing is a 25 to 50% improvement in inventory, both work in progress and finished goods, floor space and rework.

The lean vision is to generate many units, many models and many options fast.

Lean manufacturing differs from traditional manufacturing in that traditional manufacturing has production being pushed through the process in batches while lean manufacturing in contrast has production being pulled through the process by customer demand.

In other words the manufacturing process works to the pace of customer demand.

Waste is defined as any activity which consumes resources but creates no value. This includes excess production excess processing, inventory, waiting time and the motion of people and product.

The principles are as follows:

1. Specify the value of the product from the viewpoint of the customer. Ask the question - does the product disappoint the customer's expectations in regards to performance, price, quality, reliability, delivery and rapid response to changing needs?
2. Identify the value stream for each product by identifying each step required to move the product from concept to launch, order to delivery, and delivery to recycling. Challenge each step and ask if it is necessary and if the customer would like the product less if the step were removed.
3. Make the product flow. Line up all of the steps so that they run in rapid sequence. It requires each step or process to be set up correctly so that the reject rate is close to zero, the process is able to operate, and operate at the necessary capacity, and avoid bottlenecks.
4. Set it up so that the customers create pull. Tell each up-stream step to do exactly what the next down-stream step requests. Level demand by volume and mix required.

It requires a total focus on each product and its value downstream. Other distractions such as organisation structure, assets, assets and career paths are ignored. Concentrate only on those activities, which create value and eliminate those, which create waste. Eliminating waste means that the organisation generated what is needed, when it is needed and in just the amount needed.

One of the problems in going towards lean thinking is that most companies create boundaries, organisation structures, technologies and management systems that are only suited to mass production, not to lean manufacturing.

To introduce lean thinking into the organisation requires introducing a value stream management to optimize the value stream process. This generally requires that the functional expertise be rethought. Often this requires the operator to take more control of the process. In addition, lean technologies for information management and physical transformation need to be devised.

One of the guidelines of the lean movement is to borrow ideas without shame.

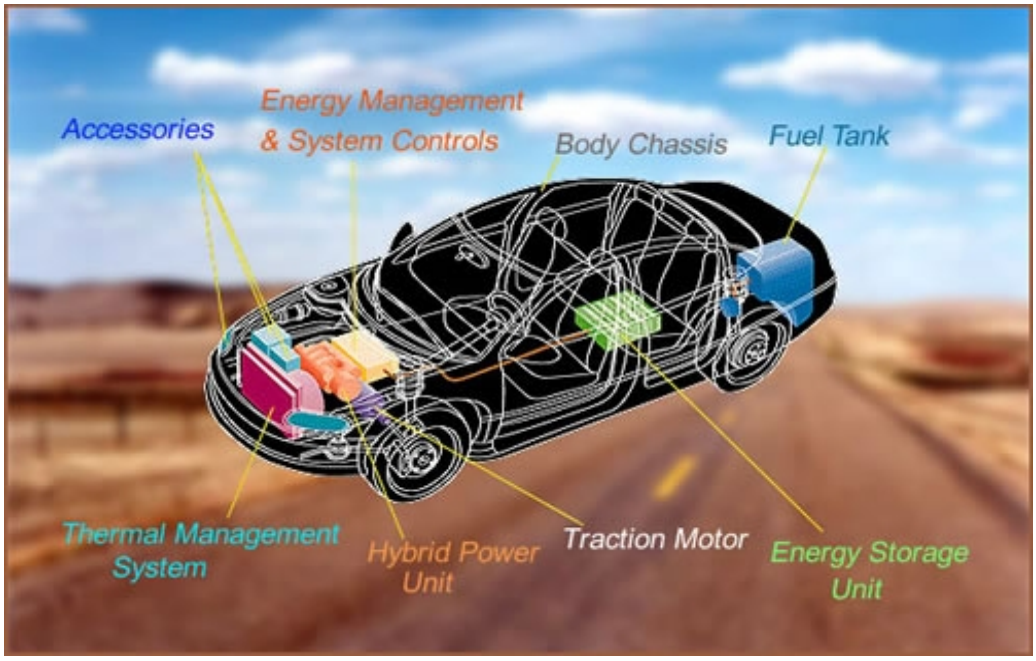
Further information can be obtained on the subject on www.lean.org.

Reported By Warren Geering

TESTING BETTER BATTERIES

Contact: Allan Chen, a_chen@lbl.gov

Building a better battery may be the key to energy-saving vehicles. The first step is testing experimental battery materials from labs around the world. Building a better battery is a key goal for those who would like to see electric and hybrid-electric vehicles become viable options in the car market. However, progress toward this goal has been slow. Many labs are seeking battery anode (negative electrode) and cathode (positive electrode) materials that will last longer, suffer less degradation, and operate safely over wider temperature ranges than is currently possible.



Hybrid-electric vehicles combine the internal combustion engine of a conventional vehicle with the electric motor and batteries of an electric vehicle, achieving twice the fuel economy of conventional vehicles.

As part of this battery research effort, a unique cell development program has been under way in Berkeley Lab's Environmental Energy Technologies Division (EETD), led by Kathryn Striebel. The project uses standardised cells to assess, in a working battery, the performance of promising new materials. The project aims to bridge the gap between materials research and commercial battery development.

EETD has long studied advanced materials for batteries. The work is currently funded by the Department of Energy's (DOE) Batteries for Advanced Transportation Technologies program (BATT), of the Office of FreedomCAR and Vehicle Technologies. BATT, administered for DOE by EETD, consists of six research tasks involving Berkeley Lab and a number of other institutions and national laboratories.

Standard cells test realistic conditions "The idea of this research element is to take new materials from labs and build them into test cells for new batteries," says Striebel. "We build new materials from different sources into these test cells and run a set of standard tests to see how they perform under realistic conditions. Then we disassemble the test cells and, after some additional electrochemical testing of our own, we send samples to the Berkeley Lab researchers focusing on diagnostic techniques, such as Raman spectroscopy, Fourier-transform infrared spectroscopy, and many others."

Experimental materials come from labs all over the world, including EETD's own electrochemistry labs. The testing helps determine why electrode materials fail or degrade. To be successful, a battery for automotive applications must meet DOE criteria for features such as weight, cost, power density, and operating temperature range.
These criteria include a 10-year life, a cost of $150 per kilowatt-hour or less, the ability to operate between minus-40 and plus-50 degrees Celsius, and a lifetime loss of capacity of no more than 20 percent. Batteries for hybrid-electric vehicles differ slightly from those for electric vehicles in that they also need to be able to provide numerous pulses of power for acceleration, as well as accept charge during regenerative braking. Currently, lithium-ion-based cells show promise for meeting these performance goals. One candidate for lithium-ion batteries is based on lithium iron phosphate ($LiFePO_4$) and natural graphite (NG).
"The central goal for us," Striebel says, "is to determine which materials work the best, and when they fail, to answer the question 'why?"

Lithium iron phosphate material has some advantages: it is stable and flame retardant, it has a long cycle life, and it shows promise for meeting the goal of no more than 20- percent capacity degradation over the battery's lifetime. However, the capacity of $LiFePO_4$ batteries is currently insufficient for use in vehicles.

Indeed, no material currently meets all of DOE's goals for automotive batteries. One important reason is that the performance of existing materials degrades significantly after many charge-discharge cycles. "Our strength is in our understanding of degradation mechanisms in battery materials," Striebel says of EETD. "If we can nail down the mechanisms of degradation, it will be a great help to everyone working in the field."

Test pouches The program's test cells are small, thin pouches just 12 square centimetres in area and hardly more than an inch on a side (about 3.5 centimetres), which can store an average of 12 milliampere-hours of charge. The effort to make a cell starts with 5 to 20 grams of an experimental material, an amount considered large for a new material, which may exist only in tiny quantities in a single lab. The material is mixed with carbon, a binder polymer, and a solvent to form a slurry. This slurry is cast in thin layers onto a foil current collector, and then dried extensively.

A few grams of experimental battery material are mixed with carbon and cast on a foil current collector (left) to make test-cell pouches 3.5 centimetres on a side (centre). Up to 64 cells are tested simultaneously (right), under conditions like those in a hybrid-electric vehicle battery.

One anode and one cathode are placed in a flexible pouch with a porous separator and transferred to a helium-filled glove box for finishing. At this point, electrolyte is added, and the pouch is sealed to protect the cell from water vapour during testing. The pouch is then compressed and mounted on a test stand, usually along with many other cells undergoing testing.

The tester can charge and discharge up to 64 test cells simultaneously, according to any specification. For example, it can run through continuous charge-discharge cycling at constant current, letting the cells rest between half-cycles which is the procedure for determining baseline cell performance, or it can charge and discharge with short, high-current pulses, simulating the conditions that a hybrid-electric vehicle's battery might encounter. The tester measures current, voltage, and other parameters, and for each test cell provides impedance characteristics, capacity, and power as a function of time or number of cycles. After a cell reaches a predetermined end-of-life limit (low capacity or power), additional diagnostic cycles are carried out before the cell is removed to the glove box for disassembly.

Once the cell is disassembled, Striebel and her colleagues may subject the experimental material to a range of additional tests to investigate its degradation mechanisms. These tests might use Raman spectroscopy, Fourier-transform infrared spectroscopy, and other spectroscopic methods; X-ray diffraction; and transmission electron microscopy. "The testing is an ongoing program," says Striebel. "We continue to test new materials as they are developed. The results allow us to compare the performance of different materials with one another." Striebel's group has also been working with that of John Newman of EETD and the University of California at Berkeley, developing computer models of battery performance. "This really helps us isolate why these materials perform the way they do."

Test results are presented at U.S. and international meetings and published in peer-reviewed journals, so the data are available to the scientific community as well as to battery developers. "Recently, we used the computer modelling directly to help in the comparison of six different sources of $LiFePO_4$ from around the world," says Striebel. "This approach generated a lot of interest at a recent meeting of the Electrochemical Society."

Article from Berkeley Lab news release

Reported by Richard Wuhrer

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OneSteel Manufacturing Pty Ltd
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Contact J Carlton 4935 4438

Oxford Instruments
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Thermo Optek Australia Pty Ltd
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Contact L Harris 9898 1244

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This list of Company Members is updated and published in the e-Newsletter on a regular basis. The purpose is to provide IMEA Company Members with exposure to the Institute's membership and the industries and organisations they represent. It is an attempt to foster and generate mutual business opportunities among our membership.

If your company's details are incorrect or incomplete, please contact:

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IMEA Sydney Branch Programme 2004

PLEASE NOTE THAT THE PROGRAMME IS SUBJECT TO CHANGE
DETAILS OF EACH EVENT WILL BE PUBLISHED IN THE
MONTHLY SYDNEY BRANCH E-NEWSLETTER

UPDATED MARCH 2004

DATE	*ACTIVITY*	VENUE
April Tuesday 20	*PLANT VISIT* ***HYDROLOGICAL SERVICES***	LIVERPOOL
May Tuesday 4	***Absence of evidence is not evidence of absence*** Guest Speaker: Tony Wells, Hawker de Havilland Ltd	PARRAMATTA BUSINESS CENTRE
Tuesday 25	*PLANT VISIT*	
June Tuesday 15	**POST-GRADUATE / INDUSTRY FORUM** UNSW, UTS, Wollongong Uni, Sydney Uni, Macquarie Uni	
July Wednesday 21	*PLANT VISIT*	
August Tuesday 17	*PLANT VISIT* **Hawker de Havilland Ltd**	BANKSTOWN
September Tuesday 21	*STUDENT PRESENTATION NIGHT* Presentations by undergraduates from University of New South Wales University of Technology, Sydney University of Wollongong	UNSW KENSINGTON
October Wednesday 20	*Loctite Seminar*	
November Friday 5	*ANNUAL IMEA GOLF DAY*	CUMBERLAND COUNTRY GOLF CLUB GREYSTANES