



# Dimensions

The newsletter from the British Society for Strain Measurement ■ January 2010 Issue 7

## Membership Survey

The BSSM has recently conducted a detailed membership survey. Thanks to all members who completed the survey - some of you have already been contacted to find out more about your comments. We are currently in the process of analysing the data and it is proposed to put a full report on the secure members-only area of the web site. Members will be notified by email when this is available. In brief most members are satisfied to very satisfied with the BSSM activity and think that the membership fee represents good value for money for the services they receive.



## Code of Practice for the Installation of Electrical Resistance Strain Gauges

This popular publication from the BSSM has been produced by the most experienced practitioners in the field, and contains the very latest procedures. BSSM members are eligible for a reduced price. To purchase or for more details please visit [www.bssm.org/cop](http://www.bssm.org/cop)



## Chairman's address – Judith Shackleton

We have had a few changes to the National Council (NATCO).

Firstly, Jimmy Eaton-Evans, Kevin Potter and Richard Greene have left us. I would like to thank them all for their support for the BSSM. Richard Greene was instrumental in organising our Annual Conference, "Advances in Experimental Mechanics VI" at the National Physical Laboratory in September 2008. Jimmy Eaton-Evans worked tirelessly on the production of our joint publication with Eureka "Modern Stress And Strain Analysis". This was a marathon task and Jimmy's energy and enthusiasm were pivotal in our success.

It gives me great pleasure to welcome a new member, Rhys Pullin. Rhys is from The Institute of Mechanical and Structural Performance at the University of Cardiff. We look forward to working with Rhys on many future events.



Judith Shackleton (BSSM Chairman)

*JMS Shackleton*

## Promote your organisation through Dimensions

To promote your organisation in Dimensions, including inserting flyers, or to advertise on the BSSM website please contact [info@bssm.org](mailto:info@bssm.org).

BSSM corporate members qualify for reduced advertising and insertion rates.



## 2010 BSSM training courses and exams



The BSSM runs a series of training courses and exams for strain gauge personnel. The courses and exams can be taken independently or in conjunction with one another. Dates for 2010 are listed opposite.

For further details or to register please visit [www.bssm.org/trainingexams](http://www.bssm.org/trainingexams)

Strain Analysis Course	Monday 11 to Thursday 14 January
Level 2 Pre-Examination Seminar	Friday 15 January
Level 2 Examination	Wednesday 27 January
Level 1 Pre-Examination Seminar	Wednesday 10 February
Level 1 Examination	Wednesday 24 February
Level 1 Pre-Examination Seminar	Wednesday 5 May
Level 1 Examination	Wednesday 19 May
Stress Analysis & Load Measurement Course	Monday 10 to Wednesday 12 May
Level 3 Pre-Examination Seminar	Thursday 13 May
Level 3 Examination	Tuesday 25 May to Wednesday 26 May
Level 1 Pre-Examination Seminar	Wednesday 14 July
Level 1 Examination	Wednesday 28 July
Strain Analysis Course	Monday 9 August to Thursday 12 August
Level 2 Pre-Examination Seminar	Friday 13 August
Level 2 Examination	Wednesday 25 August
Level 1 Pre-Examination Seminar	Wednesday 6 October
Level 1 Examination	Wednesday 20 October

## Scientific and Technical Committee (SATCO) Activities

Dr Richard Burguete of Airbus has completed his time as Chairman of SATCO and has been replaced by the current Past Chairman of the Society Professor Janice Barton of the University of Southampton. Richard should be congratulated in developing a regular series of seminars and workshops under the SATCO banner. These have been instrumental in promoting the activities of the Society and attracting new members. In January 2009 BSSM ran a very successful 'DIC showcase' at NPL; this was free to all members. It is planned that there will be one event per annum that is free to members. The next one is planned for November 2010. A new SATCO committee has been set up to include Judith Shackleton, Geoff Morden, Dr Venky Dubey, Professor Fabrice Pierron, Dr Richard Burguete,

Dr David Hollis, Dr Jerry Lord and the two BSSM executive officers Biana Gale and John Edwards. It is planned to rotate this committee every two years; if you wish to be involved please contact the BSSM. The new committee has already planned the programme for 2010 and 2011 based on feedback from members. Events will include a high speed imaging showcase, seminars on structural health monitoring and experimental mechanics of composite materials. Two strain gauge workshops will take place as well as a workshop on Residual Stress Measurement and a 5-day workshop on Experimental Mechanics. Please consult the BSSM web site for more details and watch your emails for announcements. We hope that members will support these events and spread the news to their colleagues. [www.bssm.org/events](http://www.bssm.org/events)

## BSSM 2009 Prize Winners

This year's Young Stress Analyst competition was another great success. The 2009 winner Graeme Horne said "As a finalist in the Young Stress Analyst competition, I attended the 7th International Conference on Modern Practice in Stress and Vibration Analysis free of charge. This provided an excellent opportunity to present my research and meet academic and industrial experts within the field of stress analysis. To my surprise, I was announced as the winner of the competition at the conference dinner. Besides the prize money, winning has given me enthusiasm to start my PhD and allows me to keep up to date with the community through membership of the British Society for Strain Measurement. I would thoroughly recommend applying, you could be writing this next year!" The YSA Handbook which includes all winning entries can be downloaded from the BSSM website, see below.

The BSSM Young Stress Analyst competition is an annual competition that is intended to encourage and reward young practitioners in the field of experimental mechanics. The next competition, sponsored by Airbus UK, AWE plc and Imetrum Non-Contact Precision Measurement will take place alongside the 7th BSSM International Conference on Advances in Experimental Mechanics, to be held at the University of Liverpool from the 7th to the 9th of September 2010.

For more information about the YSA including details on how to enter the 2010 competition please visit [www.bssm.org/ysa10](http://www.bssm.org/ysa10)

# YSA 09

### BSSM 2009 Prize winners receiving their awards during the MPSVA 09 conference dinner



Young Stress Analyst\* winner Graeme Horne and Caroline Bull, AWE



YSA\* Runner Up Djallal Khennouf and Paul Tatum, AWE



YSA\* 2nd Prize winner Tran Nam Nguyen and Richard Burguete, Airbus



Fylde Electrical Prize Best Paper in Strain 2008 Keith Worden receives prize from Steve O'Donnell, Fylde



Vishay Prize for joint best achievements in the BSSM L2 exams Hakan Aslan & Bulent Bektaş with Andy Wagstaff, Vishay

\* The Young Stress Analyst competition was sponsored by AWE plc, Airbus UK Ltd and Imetrum Ltd.

## Conference 2010 and EMex

7th BSSM International Conference on Advances in Experimental Mechanics 7-9 September 2010. Department of Engineering, University of Liverpool, UK.

The seventh in a successful series of conferences, the 2010 BSSM International Conference on Advances in Experimental Mechanics will offer industry and academia the opportunity to present current developments in experimental mechanics in the exciting new venue of the Department of Engineering, University of Liverpool, UK

### Conference highlights are

The BSSM Measurements Lecture: Prof. Keith Worden, University of Sheffield, UK:

'Effects of uncertainty in large nonlinear models of heart valves, particle dampers and other dynamic systems'

### Keynote lecture 1:

Prof. Ole Thybo Thomsen, Aalborg University, Denmark:

'Thermal degradation effects in polymer foam cored sandwich structures'

### Keynote lecture 2:

Prof. Josef Eberhardsteiner, Technical University of Vienna, Austria:

'Mechanical and transport properties of concrete at high temperatures'

Over 85 abstracts have been received.

### Also in the programme:

EMex, the Experimental Mechanics Exhibition

BSSM Young Stress Analyst Competition

Social programme:

Drinks Reception in the 'Street' area of the Department of Engineering

Conference Dinner at Merseyside Maritime Museum

Further details;

[www.bssm.org/conference2010home](http://www.bssm.org/conference2010home)

# EMex10

Exhibition of Experimental Mechanics

What are your views on Society activities?

Do you have an interesting technical problem you would like to solve?

Send your letters and comments to [bianagale@bssm.org](mailto:bianagale@bssm.org)



## HBM

### Piezoelectric force washers suit production monitoring applications

HBM has launched its CFW piezoelectric force washers for production monitoring applications in particular. The washers complete HBM's product portfolio of piezoelectric force sensors. The force washers are extremely compact enabling easy direct integration into the force flow, for example, in assembly and testing applications. The measuring body features a split diaphragm (patent pending) ensuring higher linearity than conventional designs. Perfect test results are attained even if forces are not applied centrally.

### Flexible temperature sensor fits curved surfaces

The TT-3/100 temperature sensor from HBM is made of a 5 µm-thin nickel measuring grid embedded between two polyamide foils making it very flexible for fitting to both flat and curved surfaces. The sensor is glued onto the component – in the same way as strain gages – resulting in excellent thermal contact and a rapid response time. Integrated solder tabs are used for connection to the data acquisition system.

### Optical strain gage with robust plastic encapsulation simplifies sensor handling

HBM has developed optical strain gages with a plastic encapsulation that significantly simplifies handling and makes the sensors highly resistant to mechanical damage. The encapsulation almost completely eliminates the possibility of a fiber break. The new optical K-OP strain gages are mainly intended for experimental stress analysis work that demands very precise measurements, even with difficult conditions and materials, and that cannot be resolved with standard strain gages. Such conditions occur, for example, in continuous vibration tests with high strain loads.

### Torque reference transducer TB2 from HBM – highly accurate and at the same time rugged



HBM's torque reference transducer TB2 is designed as a reference and transfer transducer for use in on site calibrations – for example, in the calibration of torque transducers without having to remove them from the test bench. The TB2 is available with the nominal (rated) torques of 500 Nm, 1 kNm, 2 kNm, 3 kNm, 5 kNm and 10 kNm, and is characterized by a very low measurement uncertainty. The TB2 is particularly suitable for non-rotational torque measurements. It is available with a hermetically-sealed design for use in challenging ambient conditions. In addition to extremely high accuracy, the TB2 reference transducer is characterized by its low sensitivity to parasitic influences such as bending moments and lateral forces.

Contact: [maria.hernandez-humm@hbm-uk.co.uk](mailto:maria.hernandez-humm@hbm-uk.co.uk)

## GOM

### Quality assurance on BMW convertibles:

Mobile optical 3D coordinate measuring technology is used for quality assurance on the production line in the BMW Regensburg plant. On the assembly line the photogrammetric system then enables flexible inspection to be carried out during manufacture. Thus trends and deviations in production can be detected at an early stage. As a result of using optical metrology rework time is reduced and production costs are cut down significantly. Also quality management can be specifically improved by means of process capability studies.

### Validation and Optimization of Numerical Simulations by Optical Measurement of Tools and Parts:

The simulation of deformation processes has become an important tool for the current process optimization. It can be supported significantly by modern optical measuring methods based on digital image processing providing full-field information of 3D surface geometry, deformation and strain behavior of components under load or formed sheet metal parts. These optical systems have become important tools in industrial product development cycles in the last years and together with the Finite-Element analysis they have significant potential for quality improvement and optimization of development time for products and production.

GOM's Optical Metrology Systems support companies world wide in improving faster time-to-market, enhancing product & process safety and reducing development & production costs.

Contact: [info@gom.com](mailto:info@gom.com), [www.gom.com](http://www.gom.com)

## BSSM National Council Members:

### Ms Judith Shackleton

Chairman  
Manchester Materials Science Centre, University of Manchester

### Dr Jerry Lord

Vice Chairman, National Physical Laboratory

### Mr Geoff Mordan

Honorary Treasurer

### Professor Janice Barton

Past Chairman and SATCO Chairman  
School of Engineering Sciences, University of Southampton

### Mr Ian Ramage

Honorary Secretary, Techni Measure

### Mr Ian Jones

Chairman of CERCO, Airbus UK Ltd

### Professor Margaret Lucas

CONFECO Chairman and Dimensions Editor  
Department of Mechanical Engineering, University of Glasgow

### Dr Richard Burguete

Airbus UK Ltd

### Dr David Hollis

LaVision UK Limited

### Dr Venky Dubey

School of Design, Engineering & Computing  
Bournemouth University

### Dr Rhys Pullin

School of Engineering, Cardiff University

### Dr Simon Quinn

Research Institute for Industry (RII), School of Engineering Sciences,  
University of Southampton

### Dr Bob Mines

Strain Editorial Board Representative  
Department of Engineering, University of Liverpool

LaVision

Correlation Speaks Volumes

Digital Volume Correlation (DVC) is a novel technique for 3D strain and deformation measurements across entire material volumes. Like Digital Image Correlation (DIC) which is restricted to surface measurements, DVC requires the volume images contain a random pattern; local changes in contrast due to changes in density or voids in the case of X-ray CT scans (example in figure 1). The displacement is calculated within interrogation sub-volumes and over one million displacement vectors per volume are possible. StrainMaster DVC from LaVision imports images from X-Ray CT, MRI scans, or optical tomography set-ups, and is able to quantify defects or discontinuities before they become visible in the volume image. DVC applications include biological research, metal powders, concrete structures, and composites.

Dr Jürgen Adam (Royal Holloway University London), Dr. Klinkmüller and Dr Schreurs (Bern University) have used DVC in experiments simulating geological deformation in the Earth

crust, and non-linear fault and fracture formation in brittle rocks. Having previously utilised DIC to monitor surface displacements of sand-box experiments, they are now successful in applying DVC to the analysis of X-Ray Tomography volume images. An excerpt of the impressive results is shown in the figure.

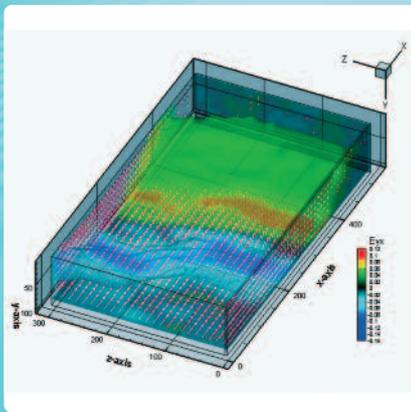


Figure: Results showing displacement vectors and shear strain isocontours at conjugate fault zones

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Member access to online presentations

BSSM members can access copies of all past seminar and workshop presentations for free by visiting [www.bssm.org/pastpresentations](http://www.bssm.org/pastpresentations)

BSSM members can only access this page using their relevant username and password. If you do not have your username and password please follow the relevant link on the BSSM home page, [www.bssm.org](http://www.bssm.org) in order to obtain your security details.

If you have any problems accessing your details please contact [info@bssm.org](mailto:info@bssm.org)



Dantec Dynamics

Robotic Shearography NDT

Dantec Dynamics delivered in 2008 a fully automatic robotic shearography system for a leading business jet manufacturer in USA. The robot system performance is capable of inspecting 1-2 m<sup>2</sup> per minute for arbitrary geometries, which is absolutely cutting edge performance in NDT worldwide. The system operates in a production environment, inside a vacuum chamber.



Figure: Robotic shearography system

It excites the production parts with vacuum and can also boost the material with up to 3 kW of heat if necessary. Objects are illuminated with 8 Laser Diodes and the shearography sensor reads out real time phase stepping results. The systems interface is constructed for being easy to operate, integrate and harmonize with a company's written practice standard, in accordance with SNT-TC-

1A or corresponding. The robot system can also be equipped with a software integrated sound excitation mode for vibration shearography through a piezo shaker or loudspeaker.

Are solutions to the energy crisis blowing in the wind?

Greater demands on efficiency of wind turbines result in continuous improvement of design, placement and performance. Given that modern wind turbines produce in excess of 6 MW, the aerodynamic loads and structural demands on the blades are increasing, being driven by the necessity for longer and lighter blades. Consequently, there is a growing need to incorporate new composite materials, making the design, manufacture and maintenance of modern wind turbines an ever increasing challenge. Dantec Dynamics has recently supplied state-of-the-art instrumentation for testing, inspecting and maintaining wind turbines.

The main applications using Digital Image Correlation and Laser Shearography are: coupon testing providing full field strain data and FEA validation, blade bending tests providing full field deformation data on a large areas, automated robotic inspection of blades at a production stage for defects such as wrinkles and disbands, in-field blade inspection via ropes or cranes for defects such as wrinkles disbands, delaminations, impact damage, and water ingress.



Figure: Q810 system on a turbine blade with detected wrinkle marked in red.

Contact Dantec Dynamics Ltd on +44(0)1275 375 333, email: [rob.wood@dantecdynamics.com](mailto:rob.wood@dantecdynamics.com) or visit [www.dantecdynamics.com](http://www.dantecdynamics.com)

## Largest Single Numerical Toolkit

### Largest Single Numerical Toolkit for MATLAB Now Available - Mark 22 Release of the NAG TOOLBOX FOR MATLAB®

Mechanical engineers seeking a broad range of mathematical and statistical functionality important to machine design and other mechanical engineering research projects without the considerable expense and bother of sourcing multiple MATLAB toolboxes, can now access 1,415 rigorously tested numerical routines in the Mark 22 Release of the multipurpose NAG TOOLBOX FOR MATLAB ([www.nag.com/numeric/MB/start.asp](http://www.nag.com/numeric/MB/start.asp)).

This one-stop solution for mechanical engineers' computing needs also allows mechanical engineers to easily and confidently migrate prototype code developed in the MATLAB environment to final production code in advanced programming languages such as C or FORTRAN while still using the same robust algorithms. NAG is renowned for the quality of its documentation and example programs to assist users. In addition, this release of the NAG TOOLBOX FOR MATLAB includes more than a dozen quickly accessible MATLAB-based examples of advanced programming for optimization problems, simulations, time series analyses and other functions important to mechanical engineering research.

Commenting on the algorithmic quality in the NAG TOOLBOX FOR MATLAB, Dr. Ning Guo of the University of Warwick, UK said, "I am especially impressed by the optimization algorithms provided. One improves my maximum likelihood estimates where sample size is small causing non-concentration likelihood. Ordinary algorithms perform poorly."

## Springer

### Springer launches SpringerMaterials

SpringerMaterials was developed for scientists in academia and research departments in industry sectors such as industrial metals, semiconductors, electrical and electronic engineering, chemicals, aerospace and defence, and oil and gas. Scientists can easily access data on material parameters for their research and rely on critically evaluated information. International experts scan the primary literature in more than 8,000 peer-reviewed journals, and evaluate and select the most valid information to be included in the database. The users of SpringerMaterials save time by gaining quick access to reliable substance properties, functional relationships and numerical data.

SpringerMaterials offers state-of-the-art search and navigation tools: user-friendly, full-text search, advanced search features and tailor-made keyword searches for speedy and smart drilling down into Landolt-Börnstein's rich content. Indispensable for a modern web database is the enriched metadata backbone, thesaurus-enabled data mining and deep indexing.

SpringerMaterials is available as a subscription database on [www.springermaterials.com](http://www.springermaterials.com)

Contact: Renate Bayaz, [renate.bayaz@springer.com](mailto:renate.bayaz@springer.com)

### Springer announces new publication

Image Correlation for Shape, Motion and Deformation Measurements - Basic Concepts, Theory and Applications  
Michael A. Sutton, Jean-José Orteu, Hubert Schreier  
2009, 364 p. 100 illus., Hardcover ISBN: 978-0-387-78746-6  
<http://www.springer.com/engineering/book/978-0-387-78746-6>

## Sensor Products Inc.

### New Generation of Body Armour Takes the Load Off Soldiers - Credit Given to Partnership of New Sensor Technology and Human Factors Engineering

Wearing body armour for protection against bullets and shrapnel has been a double-edged sword for soldiers. While the armour provides an indispensable defence, its weight and placement on the body exposes the wearer to neck, shoulder and back discomfort, and possibly years of lingering pain. To alleviate discomfort and reduce the fatigue that reduces the soldier's tactical effectiveness, a new generation of body armour systems is being developed. A body mapping pressure system by Sensor Products Inc. called Tactilus is enabling a highly-skilled team of designers and engineers to develop new vests and carriage systems that optimally distribute the load that soldiers carry. The project is being directed by KDH Defense Systems of Johnstown, PA through a contract with the US Air Force.

EDGE Product Development of Newtown, PA is using human factors engineering, design and prototyping to adapt the armour systems to the needs of the soldiers. "To enable soldiers to perform their duties with more comfort and less fatigue, we are designing body armour systems that eliminate 'hot spots' of excessive pressure during typical activities," says Daniel Massam, director of industrial design.

Dr. Evan Goldman, a professor of gross anatomy and physiology at Philadelphia University, is using the sensor

technology to test the body armour on the soldiers. When a soldier complains that they feel pressure in a certain area, the pressure points change on the computer screen and pinpoint where the vest and armour need to be redesigned to improve the pressure distribution. Besides increasing comfort, the team says the new body armour will significantly increase the soldier's flexibility and manoeuvrability, which has enormous strategic advantages in the field.

"The challenge for us in sensor technology was to modify our sensors and software to conform to the dimensions of a vest, while providing full three-dimensional pressure



Rifle with vest and body armour being tested by sensor software



Soldier running in the field being tested with sensor system

distribution visibility of the chest, back and neck," says Blume.

Jeffrey Payne, Project Manager of KDH Defense Systems, says the project is on track to meet its goals. "Most armour designs today are from within the armour industry, but by using a human factors company like Edge that thinks outside the box, we come up with unique and innovative approaches to better protect the soldier," says Payne. "Armour designs today are over the body and wrap like a jacket. Edge looks at applying different ways to take off loads, making the vest and armour wrap around the wearer so tightly that it becomes load bearing," adds Payne.

Contact: Sensor Products Inc., [info@sensorprod.com](mailto:info@sensorprod.com), [www.sensorprod.com/bodymapping.php](http://www.sensorprod.com/bodymapping.php)

### Sigmapi Systems Ltd.

#### BAE Systems uses LOWSTIR to optimise welding processes

Friction Stir Welding (FSW) is a welding process invented by TWI in 1991. The process involves a spinning tool, in contact with the material to be welded, with sufficient down force to create frictional heat in the material (about 80% of the material's melting point). This causes the material to become soft, allowing the spinning tool to create the weld. FSW has significant advantages over other joining techniques including good mechanical properties, low distortion, and an ability to weld some materials that cannot be welded by other methods. Most current uses involve the joining of Aluminium alloys, for applications including: airframes, aircraft components, ship decking, rail carriages, automotive components and space launch systems.

Unlike other friction stir welders, the LOWSTIR friction stir welding system includes a unit that attaches to most standard milling machines via an ISO taper, making it an affordable option for smaller enterprises. It is supplied with software to calibrate the system, monitor the welding process and log welding parameters for later analysis. However, standard milling machines lack the process monitoring capabilities required to ensure high quality friction stir welded joints. LOSTIR (no 'w'), the original project part funded by the European Commission in 2005 developed a low cost FSW monitoring system for retro fitting to milling machines to facilitate their application to FSW. This process used a bespoke sensing head incorporating the tool holder, electronics, a ceramic heat shield and rotating antenna for transmission of the data to a stationary receiver, mounted onto the frame of the machine. The receiver is connected via cables to a signal processing module, computer and mains power supply.



Figure: Original system in action incorporating revolving antenna and static receiver

Whilst this system has been used successfully for a number of years, the use of telemetry for the signal transmission means an antenna/receiver arrangement is necessary complete with cable connections. Additionally the electronics mounted within the sensing head are subject to severe vibration and heat. To ensure the forces from the welding process do not affect the electronics and gain the benefit of a wireless system, the sensor head has been modified to use a battery power supply and a Bluetooth connection to transmit machining data to a stationary receiver I.E. a notebook computer fitted with a standard Bluetooth module. This modification means that the sensitive electronics and rotating antenna for the telemetry transmission is no longer required, nor are the stationary receiver or the signal processing unit, power supply or associated trailing cables. The original design has been considerably revised to accommodate these changes, resulting in a reduction in the size of the sensor head, making it both lighter and stiffer.

Andy Wescott of BAE's Advanced Technology Centre says one of the biggest problems with welding aluminium is distortion. However with the appropriate clamping in place and due to there being less heat generated by the process, this problem is largely overcome. A further benefit of using FSW is that high strength aluminium alloys can be welded, a process

not possible using traditional techniques. Also recent trials have demonstrated FSW can be used to repair localised damage to large panels. Rather than replacing a large area with a single sheet of material at the existing weld or join, just the damaged area is repaired with a slug of new metal which is welded 'in-situ' leaving no step or change in the contour of the original material. This saves time and money compared to larger repairs requiring more specialised equipment or a return of equipment to workshops. Additionally as it uses vastly less energy in the process, all told it is a very 'green' technique.

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### AFL Telecommunications

#### Rodded Optical Fiber

AFL's Rodded Fiber takes an optical fiber of the customer's choice and encases it in a glass re-enforced matrix. The diameter of the structure is adjusted to provide the characteristics needed for the specific application. The performance of the optical fiber is retained in this structure providing for a very ruggedized fiber suitable for many harsh applications. The Rodded Fiber is best suited for high tensile or compressive requirements where the glass structure provides the rigidity to protect the optical fiber from harm. Additionally, AFL's Rodded Fiber does not exhibit the typical curvature coming off the payoff reel like that of most cables. This makes deployments in applications such as pipelines and oil wells simpler. Applications such as strain sensing and temperature sensing in a host of environments up to 200°C are ideal for this product.



Figure: Rodded optical fiber

#### Features/Options

- Strength – Variable as glass matrix diameter can be increased which will increase the strength
- Bend Diameter – 50x the outer diameter
- Temperature Performance – Standard is 100°C (200°C option)
- Ruggedized Option – Product can be jacketed with various polymers such as PVDF, Hytrel, Polyethylene, Nylon, PVC, Fire Retardant PE, Polyurethane and others

Contact: Graham Small, gsmall@afl-europe.com

Please visit the  
BSSM website at  
[www.bssm.org](http://www.bssm.org)  
for more information  
about forthcoming  
BSSM events



## Full-field measurements for the mechanical characterisation of low density polymeric foams

Low density polymeric foams are widely used in applications that require good low energy absorption capabilities, such as in packaging for instance. However, the determination of their mechanical properties is made difficult because of their hyperelastic behaviour and strong localization effects caused by the local collapse of cells in compression. For the present material, the latter is due to elastic buckling of the cells in compression, with total recovery of the initial cell shape after unloading, resulting in the hyperelastic behaviour. Trying to address such a complex mechanical behaviour with just a global stress/strain curve is extremely difficult. It is therefore essential to bring in more experimental information and optical full-field deformation measurements provide a great opportunity to improve the identification procedures for this type of materials.



Figure 1: Compression test set-up

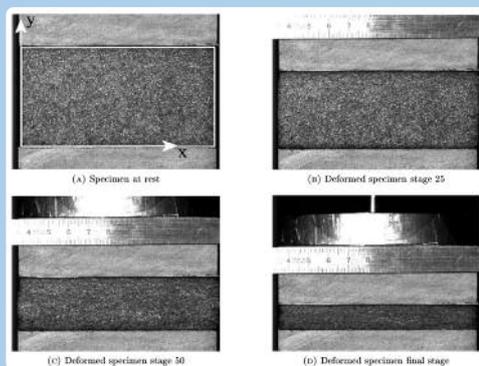


Figure 2: Different stages of compression

as can be seen below. The material was a low density polyurethane foam (30 kgm<sup>-3</sup>), typical of packaging applications

From these displacement maps, incremental strains (between two consecutive steps) have been calculated using an adapted smoothing – differentiation procedure [1]. Fig.3 shows a few such strain maps. It can be seen that the deformation process is highly heterogeneous. At the beginning (top row), the deformation initiates at the specimen to fixture boundary, whereas the rest of the specimen does not deform at all. Then, the deformation propagates as 'bands' in the specimen. This corresponds to the gradual elastic collapse of whole rows of cells. Finally, at around 0.3 compressive strain, compaction is over and the strain state becomes uniform.

A consequence of this is that if Poisson's ratio is extracted from these data by the usual uniform approach [2], the blue curve on Fig. 4 is obtained, where Poisson's ratio is initially high (for the non collapsed cells) and decreases towards zero (for the collapsed cells). However, this information is not intrinsic to the material. Indeed, looking at the second row images in Fig. 3, some part of the specimen are highly deformed whereas others are not. Therefore, a Poisson's ratio calculated from such a map will produce some sort of spatial average of the information. The use of full-field

Digital image correlation is a good tool to measure the deformation of such materials as they exhibit large strains and have a natural texture for the correlation. Fig.1 shows a view of the compression test set-up (the foam specimen is the grey bloc). About 80 images were taken during the test. Four examples are given in Fig. 2, the top left and bottom right corresponding

respectively to the first and last images. The Correli image correlation software was used to calculate the displacement maps at all stages, using an incremental formulation because the speckle pattern changes dramatically during the test,

measurements enables however to process this information differently. By selecting on all maps the parts of the specimen that have a strain between certain bounds, then Poisson's ratio can be calculated as constant over a certain strain range with information gathered from the whole test. This is what is represented in red in Fig. 4 (24 strain intervals where used). One can see that the initial Poisson's ratio is highly underestimated by the usual procedure. At very low strains, it is in reality much closer to 0.5 (incompressible material). Up to about 0.15 of compressive strain, rather large differences exist between the two results which then converge together as the strain field becomes more uniform. This is a good example of how full-field measurements can be used to better

understand and identify the mechanical behaviour of materials by taking into

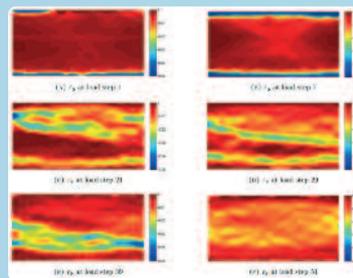


Figure 3: Incremental compressive strain

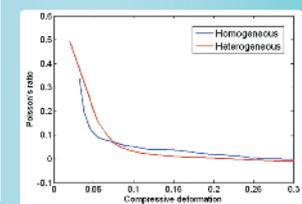


Figure 4: Poisson's ratio

account localization phenomena. As for such foams, a lot of work remains to be done to define testing procedures and identification routines based on full-field measurements to better identify hyperelastic mechanical models.

### References:

- [1] Avril S., Feissel P., Pierron F., Villon P., Estimation of the strain field from full-field displacement noisy data: comparing finite element global least squares and polynomial diffuse approximation. *European Journal of Computational Mechanics*, vol. 17, no. 5-7, pp. 857-868, 2008.
- [2] F. Scarpa A. Bezazi. Mechanical behaviour of conventional and negative Poisson's ratio thermoplastic polyurethane foams under compressive cyclic loading. *International Journal of Fatigue*, vol. 29, pp. 922-930, 2007.

### Acknowledgements:

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## New eBook

An e-Book on Experimental Stress Analysis (ISBN: 978-81-904235-6-4) authored by Prof. Krishnamurthi Ramesh, Member of the Editorial Board of Strain, has been published by IIT Madras. The book is innovative in many ways and makes a novel attempt to smoothly integrate experimental results in real-time to have a laboratory experience in a lecture class.



The e-Book exhaustively covers such famous techniques as photoelasticity and strain gauges and provides fundamental aspects of eight other techniques such as Moiré, brittle coatings, holography, speckle methods, thermoelastic stress analysis, digital image correlation, caustics and coherent gradient sensor. In addition it has a comprehensive and state of the art treatment of digital photoelasticity.

The book has 100 hours of teaching/learning material in a single DVD. With judicious planning, the material in the book can be used in a variety of ways to suit different audiences.

For more details about the book and to download a demo version visit the site: [http://apm.iitm.ac.in/smlab/kramesh/book\\_5.htm](http://apm.iitm.ac.in/smlab/kramesh/book_5.htm)

## Photoelasticity revived for Tactile Sensing

Photoelasticity has been traditionally used for experimental stress analysis, however, use of this technique is not very well explored in sensing applications, especially by analysing the fringe patterns. The main challenge involved is to extract load information from the fringe patterns, as there may be an infinite number of load settings for the same resulting fringe patterns.

The photoelastic effect is exhibited by certain non-crystalline materials that are ideally isotropic but behave anisotropically when loaded, showing birefringent characteristics at a very low level of straining. The effect is temporary and persists only until the specimen is loaded. This property of material has been used for dynamic or wave propagation studies, however, the effect can be potentially used for sensing applications if the fringe information can be precisely quantified in terms of stress distribution. This has been used for developing a number of discrete signal-based sensors for biomedical applications. A novel dynamic tactile sensor based on this effect has been developed at Bournemouth University, which is capable of detecting object slip as well as providing contact force [1]. The advantage of using this material for such applications is to retrieve two contact stimuli from the same location which may be useful in many control applications such as object grasping similar to that of a human hand. A typical output from the photoelastic sensor is shown in Figure 1, which generates contact force as well as slip signals from the same contact location.

Recently there has been a spurt of interest in developing whole-field tactile sensors; photoelasticity may be the right technique for such sensing applications. A photoelasticity based imaging sensor may find wider applications in term of actual loading and visualisation as the material develops coloured fringes that contain details of the loading conditions. The advantage of using this technique is to obtain whole-field visualization of the stress field, which may provide load information of the entire field as opposed to employing strain gauges, or load cells that only offer discrete load information.

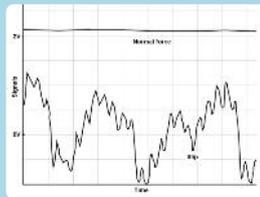


Figure 1. Tactile signals from a photoelastic sensor

Figure 2 shows a foot imprint from a prototype sensor developed at Bournemouth University based on photoelasticity. Once this technique is fully developed, it could find applications in biomedical sensing areas such as early detection of diabetic foot ulceration or assessment of pressure sores in disabled subjects, thereby enacting prevention strategies by suitable footwear or bed designs.

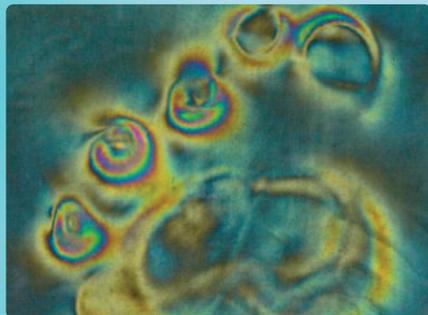


Figure 2. A whole-field tactile sensor based on photoelasticity

The application of photoelasticity in sensing is, however, full of challenges. For example, it requires use of low modulus photoelastic material that can have a wide dynamic range and is sensitive to different loading conditions; the loading has to be applied in the direction of imaging in the case of a whole-field sensor, this requirement makes the conventional photoelastic technique depart from the existing one. This may be further compounded due to generalised loading conditions and out-of-plane deformation of the material, thus this may require some intelligent processing of the images [2]. Nevertheless, this has

ushered in a new area of research which will revive this field, as it did when FEA techniques were verified alongside experimental results from photoelasticity. The technique looks ever more promising with the advent of high computing power and low straining photoelastic material that can lend itself to dynamic tactile sensing for real time applications.

For further detail contact:

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[1] Dubey, V. N. and Crowder, R. M., 2006 "A dynamic tactile sensor on photoelastic effect" Sensors and Actuators, 128: 217-224.

[2] Dubey, V. N. and Grewal, G.S., 2009 "Efficacy of photoelasticity in developing whole-field imaging sensors" Optics and Lasers in Engineering (in press).

If you have a story which you would like included in the next issue of Dimensions please contact the Editor, Professor Margaret Lucas at m.lucas@mech.gla.ac.uk



## BSSM Diary of Events

- 11-14 January Strain Analysis Course
- 15 January Level 2 Pre-Examination Seminar
- 27 January Level 2 Examination
- 10 February Level 1 Pre-Examination Seminar
- 24 February Level 1 Examination
- 10 March The Measurement of Residual Stress using Diffraction Methods Workshop
- 11 March New Approaches for Performance Definition of Composite Materials and Structures
- 22-26 March Workshop on Experimental Mechanics
- 27-28 April MTEC
- 5 May Level 1 Pre-Examination Seminar
- 19 May Level 1 Examination
- 10-12 May Stress Analysis & Load Measurement Course
- 13 May Level 3 Pre-Examination Seminar
- 25-26 May Advanced Structural Health Monitoring
- 25-26 May Level 3 Examination
- 23 June Strain Gauge Workshop
- 14 July Level 1 Pre-Examination Seminar
- 28 July Level 1 Examination
- 9-12 August Strain Analysis Course
- 13 August Level 2 Pre-Examination Seminar
- 25 August Level 2 Examination
- 7-9 September 7th BSSM Conference on Advances in Experimental Mechanics
- 8 September EMex 10 - Exhibition of Experimental Mechanics
- 29 September Strain Gauge Workshop
- 6 October Level 1 Pre-Examination Seminar
- 20 October Level 1 Examination

For further information on these events please contact John Edwards, tel: 01234 347778, e-mail johnedwards@bssm.org or visit the BSSM website at www.bssm.org

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