

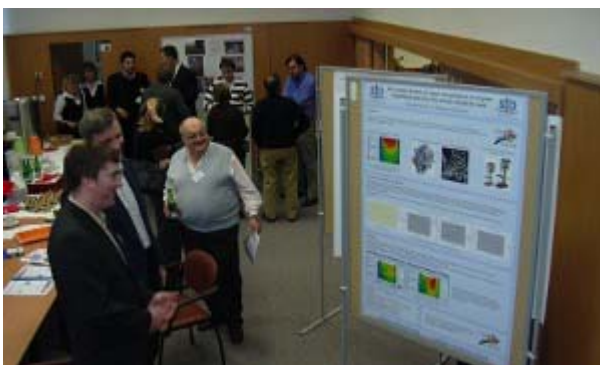
MML European User Meeting 2009 – Review



The ninth MML European User Meeting was held at the Institute of Physics at the Academy of Sciences of the Czech Republic, in Prague. The meeting was kindly hosted by Dr Petr Bohac and his group.

The opening session of the meeting was chaired by **Dr Bill Clegg** of **Cambridge University**.

Prof Jaroslav Mencik of the **University of Pardubice** opened the session with a discussion on the determination of time dependant properties using nanoindentation. The talk featured a comprehensive review of the issues surrounding the use of traditional quasistatic nanoindentation to investigate materials exhibiting creep behaviour. The speakers argued that the parameters in creep compliance function ($C_0, C_1, C_2, \dots, t_1, t_2, \dots$) are best found from the time course of indenter penetration under constant load.



Iryna Valieieva of the **Institute for Problems in Materials Science, Kiev** presented a range of data acquired on aluminium films. Iryna and colleageues developed a technique for deriving yield stress and strain-hardening exponents of film material from the acquired indentation data.

Dr Georgios Constantinides of **Cyprus University of Technology** presented some excellent data acquired using the liquid cell. The performance of the liquid cell was validated by investigating water-insensitive materials under normal 'dry' conditions, and when submerged in liquid. Results showed that there were no artifacts from buoyancy or surface tension, thanks to the horizontal loading mechanism employed by the system. Results for a range of porous materials, such as hydrogels, tissues and geomaterials, all submerged in a liquid were presented. The system was shown to accurately characterise materials in the kPa to GPa range.

The second session of the day was chaired by **Prof Jaroslav Mencik** of the **University of Pardubice**.

Dr Bill Clegg of **Cambridge University** opened the session with a lively discussion of micropillar compression at elevated temperatures. Dr Clegg's group have carried out compression tests using a flat punch indenter, at temperatures ranging from room temperature up to 400°C, and these results were presented. Data shown covered a range of slip systems, and was compared with bulk values obtained.



Michael Davies of the **University of Nottingham** detailed the work he has carried out on wear-resistant tool coatings. Tool coatings often operate under high temperature conditions, and to reflect this their performance was characterised at temperatures from room temperature up to 750°C. In order to reduce the effects of oxidation on the samples testing was carried out in an Argon atmosphere. This was shown to be a very effective solution. The speaker gave some good advice on choice of indenters and recommended system stabilisation times at high temperature.

Gerard Bell of the **University of Birmingham** presented a sub-ambient temperature nanoindentation capability which has been developed in conjunction with MML. The modified NanoTest system uses a purging chamber together with localised indenter and sample cooling. The speaker presented data acquired from a range of polymeric samples, carried out in the range +28°C to -30°C. H and E_r values were seen to increase by 100% to 150% over the temperature range investigated.

Prof Ben Beake of **Micro Materials Ltd** and **Manchester Metropolitan University** spoke on the optimisation of hard nanocomposite thin films, discussing whether it's preferable for a hard film to be ultra-hard or ultra-tough. Work carried out on TiFeN, TiN and TiFMoN films was presented, with the speaker showing how some films with a very high H/E ratio failed dramatically at low loads, while those with a slightly lower H/E possessed a more optimal combination of hardness and toughness for applications where they could be exposed to high shearing forces.

The third session was chaired by **Dr Georgios Constantinides** of **Cyprus University of Technology**.

Prof Pasquale Vena of **Politecnico di Milano** opened the session, with a talk focussed on the application of thin alumina coatings in the field of biomedical orthopaedic devices. Both homogeneous Alumina and functionally graded Alumina-Titanium coatings were investigated using indentation and scratch testing. In order to characterize the spatial gradient in composition, analysis parameters P/h^2 or the dimensionless parameter $P/(Erh^2)=\Pi$ were used.

In an ideal experiment (perfect tip and homogeneous material), the ratio $P/h^2=Er\Pi$ is a constant directly related to the hardness of the material. In this study, the P/h^2 ratio clearly discriminated FGM coating, which exhibits a P/h^2 ratio decreasing with depth.

Dr Karlis Gross of **Riga Biomaterials Innovation and Development Centre, Latvia**, presented his work on the nanoindentation of microfabricated surfaces. Dr Gross showed how well defined surface features could be targeted during nanomechanical testing, showing work he has carried out on solidified droplets. Interesting work on the effect of indentation angle was also presented.

Kazim Altaf of **Loughborough University** concluded the session with his innovative work on the effect of humidity on the mechanical properties of stereolithography resins. The NanoTest humidity control was used to alter the relative humidity (RH) from 45% up to 95%. The effect on the mechanical properties of the samples was extensive, in one of the samples moisture absorption reduced the values of E and H by 95% and 92% respectively.

Tested samples were then kept in controlled ambient conditions for 10 days and retested in order to see if there was any recovery in mechanical properties. Both materials tested were seen to recover.



The final session of the day was chaired by **Dr Ben Beake** of Micro Materials Ltd.

Vitor Marques of **Oxford University** opened the session with the work he has carried out on the nanomechanical analysis of lead-free solders for use in high performance microelectronics systems. Vitor detailed the work he has done to evaluate hardness, elastic modulus and creep behaviour of micro-phases formed in Sn-AG-Cu/Cu solder joints,

at temperatures from 25°C to 175°C.

Vitor also presented finite element analysis which can be used to better understand the creep data.

Dr Norbert Schwarzer of the **Saxonian Institute of Surface Mechanics** offered a critical review of dynamic/ oscillatory measurement procedures, giving the audience an overview of the flaws in the assumptions made during such measurements. He went on to offer some solutions to these flaws, and other items for consideration during testing.

Dr James Dean of **Cambridge University** presented some very recent work on copper foils in which equal biaxial residual stresses were generated. The copper foils were then indented and the peak indentation load at maximum indenter depth was recorded as a function of the pre-indentation residual stress. Hardness data, also as a function of pre-indentation residual stress, were also obtained. Detectable decreases in the peak indentation load with increasing (tensile) residual stresses were observed, even for small changes in the pre-indentation residual stress. In contrast, no discernable change in the measured hardness data was obtained. These results are consistent with FE predictions. Using the FE model, and knowing the constitutive relation governing plastic deformation of the material, this nanoindentation data could be used to evaluate residual stress levels, with good sensitivity.

Denise Hoban – 15/01/10

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