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1) BS EN ISO 14577-1:2015 2) Oliver, W.C., Pharr, G.M.:J. Mater. Res., 1992, 7, (06), pp. 1564–1583. 3) G. Feng, A.H.W.N.:J. Mater. Res., 2002, 17, (03), pp. 660 – 668. 4) Shah A, Renevier N, Sherrington I., UK Patent Application Number 1513480

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A UNIVERSAL CHARACTERIZATION METHOD ON VISCOUS MATERIALS USING DEPTH SENSING INDENTATION

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Key Words: Nanoindentation; Method; Polymers; Creep; Plastic depth

Miniaturisation of devices and a paradigm shift toward using compliant material require small scale characterisation techniques such as nanoindentation [1]. Initial non-conformity of contact and delayed elasticity on the unloading curve are not currently taking into account in nanoindentation methods [2, 3], where the unloading curve is seen fully elastic. A different approach has been taken which considers actual localised deformation during nanoindentation, thus the proposed method [4] is able to acquire untainted elastic or viscoelastic response data. The method, validated for both viscous and non-viscous materials, takes into account the correction of the stiffness associated with the delayed elasticity at initial unloading and determines modulus with less variability even if testing conditions are non-quasi-static. The key step in the methodology is to account for initial conformity of the contact, the nose-out phenomena and delayed elasticity. Thus a full elastic point (FEP) is determined as seen in the figure 1. Traditionally to eliminate the initial delayed elastic response a multi-cycle approach was needed, whereas in our method any materials, even viscous, can be tested under any test conditions in a single loading-unloading cycle. The algorithm is universally applicable. Experiments were conducted on six different viscous materials under single and multi cycle loading conditions to validate our method to existing ones [2–3]. Multi-cycle test on PET & PEN are reported in figure 2. It was found that except for rubber all the different materials studied by using just a single-cycle, our method determined values equally well as previous Oliver and Pharr method [2] with less variation. For multi-cycle tests our method is capable of producing results as good as the fourth-cycle of Feng's method [3], thus time and cost of experimentation can be reduced. So this method becomes appropriate as a standardised technique, and also for the characterisation of polymers which have been an issue in the past.

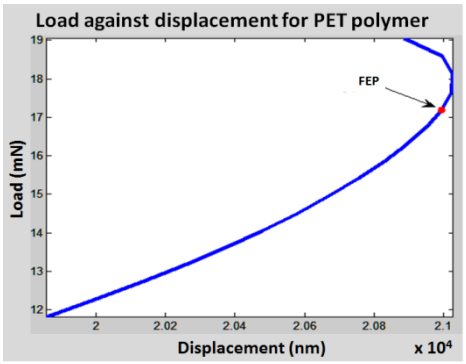

Figure 1 Load-displacement plot for PET

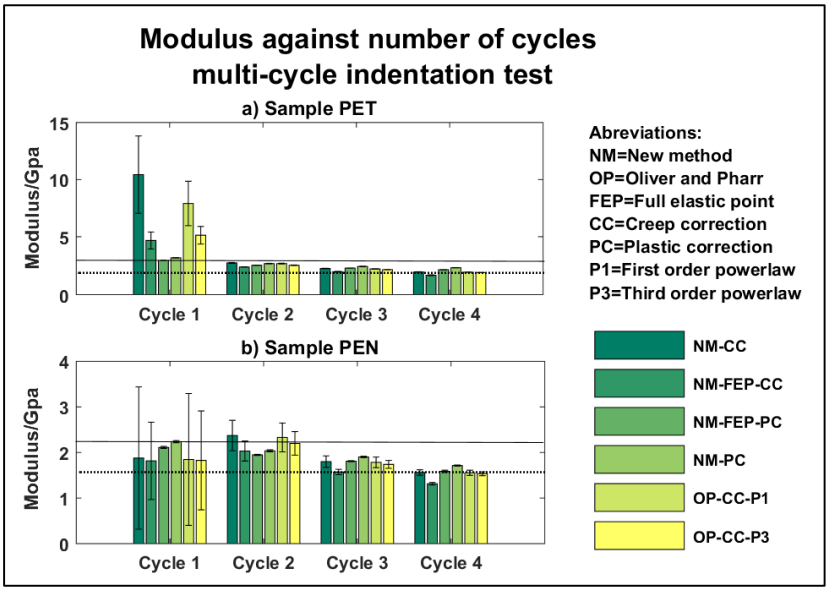

Figure 2 Modulus results against different methods using multi-cycle tests for a) PET & b) PEN

References

1) BS EN ISO 14577-1:2015
2) Oliver, W.C., Pharr, G.M.:J. Mater. Res., 1992, 7, (06), pp. 1564–1583.
3) G. Feng, A.H.W.N.:J. Mater. Res., 2002, 17, (03), pp. 660 – 668.
4) Shah A, Renevier N, Sherrington I., UK Patent Application Number 1513480.2.