

# Micro Hardness Determination of Cured Lacquer on Thin Polymer Film Substrates

## 1. INTRODUCTION

Characterisation of non metallic films on polymer substrates is very important when the materials are being used in applications which require the films to give certain surface properties for providing resistance to impact, scratching and general wear while in use. This report describes the methodology for evaluation of hardness of coated polymers and thin films for touch screen applications.

## 2. INSTRUMENTATION

The instrument used for this exercise is the Fischerscope HM2000S.



## 3. MEASURING PRINCIPLE

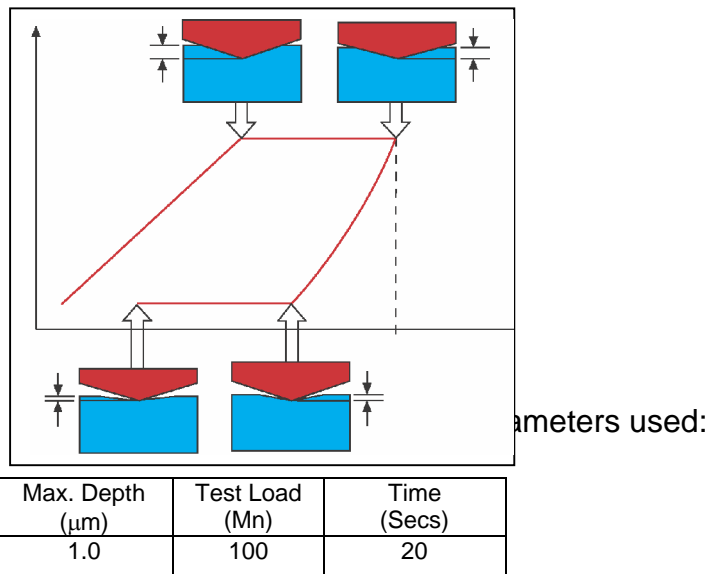
The Fischerscope HM2000S a load/indentation depth method according to ISO 14577-1. Using an intelligent load cell with user defined final load value, the Vickers indenter is continuously pressed into the material test piece with an increasing test load, and then unloaded. The respective indentation depth is measured at the same time. Taking into account the geometric relationship between the indentation depth and shape of the indenter, this measurement produces the Martens Hardness HM ( $HM = F/A$  where A represents the surface of the penetration). From this a variety of material properties and characteristics can be automatically determined including conversion of the direct measurement of indentation hardness ( $H_{IT}$ ) into Vickers (HV).

## 4. DISCUSSION

The samples in this investigation consist of a range of polymer films with a total thickness of approximately  $120\mu\text{m}$ . These films have then been coated with a lacquer that has been cured to various levels to achieve the

required hardness for the properties as discussed. The approximate thickness of the lacquer is 4-5 $\mu\text{m}$ . Characterisation of thin films such as these and in particular relatively soft materials can be difficult to achieve realistic measurements due to the thickness and therefore impeding the measurements onto the substrate material. In this event the HM2000S has the ability to measure thin-coated samples using the depth rather than load technique to control the penetration of the diamond indent. For this investigation the maximum depth of penetration is set to 0.50 $\mu\text{m}$  with a test load of 100Mn. The measurement must be a direct measurement of the coating without any interference from the underlying substrate. In order to reliably determine the hardness of a layer, the indentation depth must not exceed 1/10<sup>th</sup> of the total layer thickness in accordance with ISO 14577-1. The Fischerscope HM2000S is optimally suited to this application such that the user can predefine the load and the maximum depth of penetration into the test sample giving full control of the test procedure. When measuring polymeric materials we can use Martens Hardness (HM), which gives a direct test of F/A in N/mm<sup>2</sup>. This will be a comparative technique to distinguish small changes in hardness between samples with different curing times. The curing times however are unknown for this application. The results can be seen in tables 1 & 2.

**Fig.1 shows schematic presentation of measurement cycle**



## 6. RESULTS

Tables 1 and 2 shows results taken from 4 measurements on each sample.

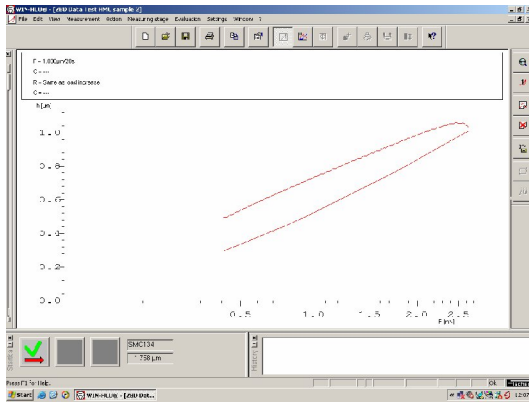
**Table 1**

Sample 1		Sample 2	
No.	HM (N/mm <sup>2</sup> )	No.	HM (N/mm <sup>2</sup> )
1	44.8	1	128.4
2	45.5	2	127.2
3	44.7	3	123.9
4	45.2	4	138.6
% V	SD	% V	SD
0.82	0.37	4.91	6.36

**Table 2**

Sample 3		Sample 4	
No.	HM (N/mm <sup>2</sup> )	No.	HM (N/mm <sup>2</sup> )
1	124.7	1	101.4
2	124.9	2	98.2
3	122.1	3	99.0
4	124.0	4	101.2
% V	SD	% V	SD
1.00	1.24	1.57	1.57

**Fig.1 shows graphical representation of load/unload curves for samples 1 and 2**



## 7. CONCLUSIONS

It can be seen from the results that the reproducibility of measurements from this instrument is exceptional keeping in mind that the measurement is totally dynamic without the need for visual inspection, and in any case visual inspection is not valid when we consider the parameters for this test.

The results show three stages of the curing process and therefore three different degrees of hardness. Range 1 exists at approximately  $45 \text{ N/mm}^2$ , range 2 exists at around  $100 \text{ N/mm}^2$  and range 3 at approximately  $130 \text{ N/mm}^2$ . When we consider the reproducibility of these measurements we can assume that a realistic measurement is achieved from different stages of the curing process.