Significance of fitting parameters in Indentation

A.S.Bhattacharyya $^{1,2}$*, R. Mandal$^1$

$^1$Centre for Nanotechnology and $^2$Centre of Excellence in Green and Efficient Energy Technology (CoE-GEET)
Central University of Jharkhand, Ranchi – 835 205, India,
*e-mail: 2006asb@gmail.com; arnab.bhattacharya@cuj.ac.in

The fitting relations for Vickers’s indentation for SiCN films as obtained previously are given below [1]. The parameter P’s are the ones which quantify the thin film hardness and substrate effect. The Variation of Hardness with thickness for different $P_1$ values was given in our previous publication. Here we provide the variation of hardness with other parameters.

$$H = P_1d^4 + P_2d^3 + P_3d^2 + P_4d + P_5 (4^{th} \text{ order fit})$$

The variation of hardness with $P_2$, $P_3$, $P_4$ and $P_5$ for different thickness (1- 5 µm) are shown in Fig 1- 4. We can see that there is a decrease in hardness with increase in $P_2$ and the rate of decrease is higher for higher thickness. Interestingly a reverse effect of increase is observed in hardness for $P_3$ and also the rate is not monotonically increasing or decreasing with thickness and shows highest rate of increase for 4 µm. The difference in the rate of decrease is much lower for $P_4$ and almost
constant for P5. We can see that the variation in hardness with thickness was maximum for P3 and least for P5 (Fig 5).

We can associate P2 as well as P4 with tip sharpness as sharper is the tip the lesser will be the hardness. The effect of pile up can also be associated with P2 as higher is the pile up lower will be the hardness.

P3 on the other hand can be associated with tip bluntness, work hardening as well as sink in effect. Consequently the harness shows an increase with P3. P5 is simply a constant hence shows no change with its increase.

The abrupt change for thickness of 4 µm is an indication of optimized thickness showing the best possible properties which has also matched with experimental results [2].

From fig 5 we can also observe that the most dominating parameter has been P3 in this case as the variations are more vivid (Fig 5 (b)) compared to others. Hence we can also say that for SiCN, the sinking and tip blunting have been significant.

However the tip blunting or sharpening is much more significant for nanoindentation [3] and so in this case we shall stick to the fitting P parameters define the material properties more than indentation methodology.
Figures:

Fig 1: Variation of hardness with $P_2$ values for different thickness

Fig 2: Variation of hardness with $P_3$ values for different thickness
Fig 3: Variation of hardness with $P_4$ values for different thickness

Fig 4: Variation of hardness with $P_5$ values for different thickness
Fig 5: Variation of Hardness with thickness for different a) P<sub>2</sub>, b) P<sub>3</sub>, c) P<sub>4</sub> and d) P<sub>5</sub> values

Reference

1. Arnab S. Bhattacharyya, R. Praveen Kumar, Rohit Mandal, Nikhil Kumar, N. Rajak, Abhishek Sharma, Shashi Kant, Substrate effect and nanoindentation fracture toughness based on pile up and failure, 2016, arXiv:1602.07657[cond-mat.mtrl-sci]
