Significance of fitting parameters in Indentation

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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.

$$H=P_1d^4 + P_2d^3 + P_3 d^2 + P_4d + P_5 \ (4^{th} \ order \ fit)$$

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 P4 and almost

constant for P5. We can see that the variation in hardness with thickness was maximum for P_3 and least for P_5 (Fig 5)

We can associate P_2 as well as P_4 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.

P_3 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 P_3. 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 P_3 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:

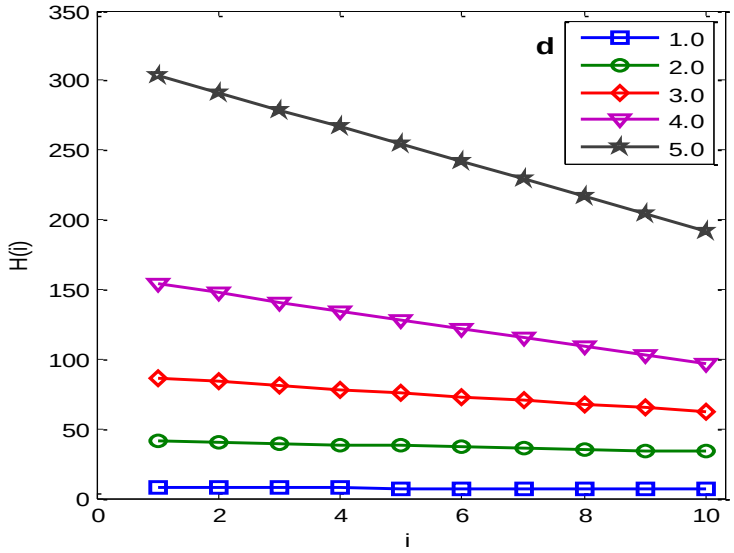

Fig 1 : Variation of hardness with P_2 values for different thickness

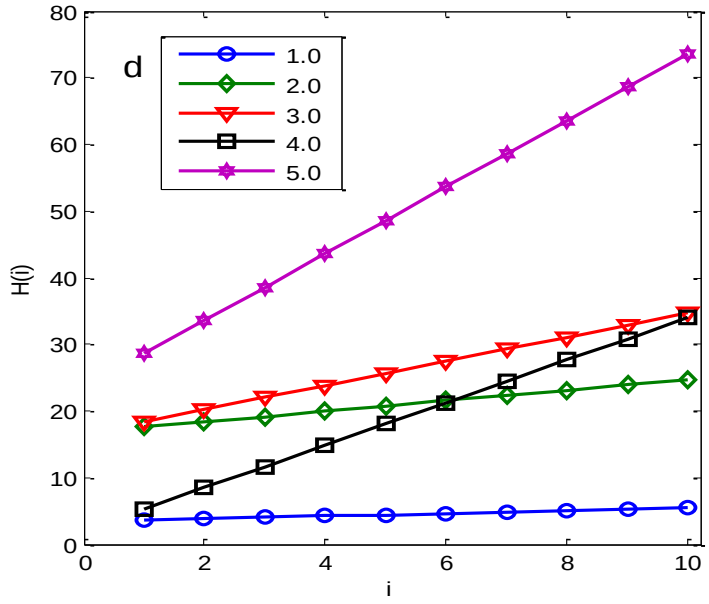

Fig 2 : Variation of hardness with P_3 values for different thickness

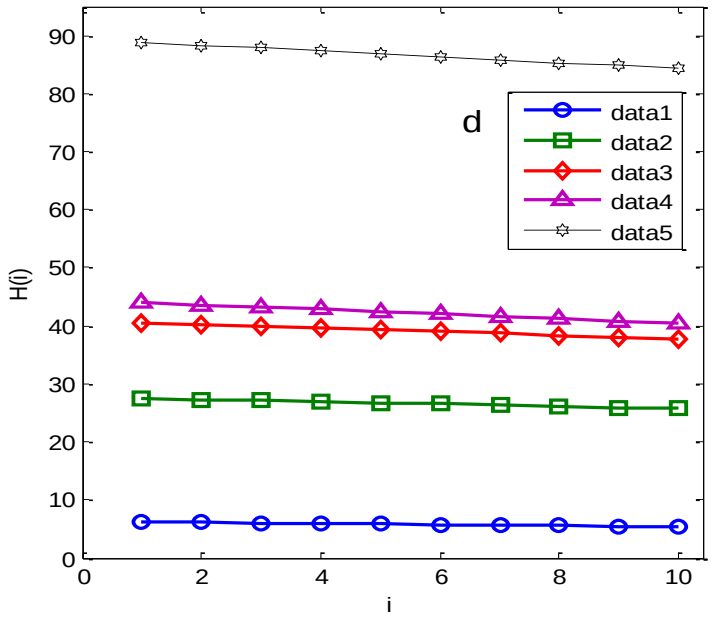

Fig 3 : Variation of hardness with P_4 values for different thickness

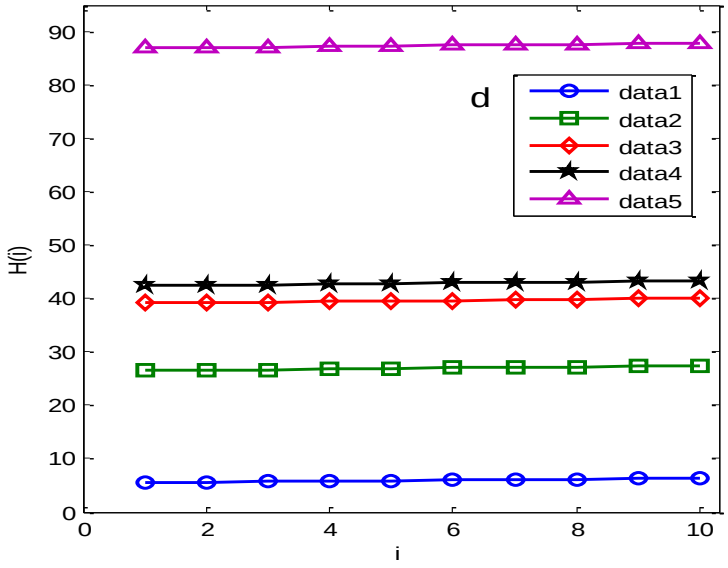

Fig 4 : Variation of hardness with P_5 values for different thickness

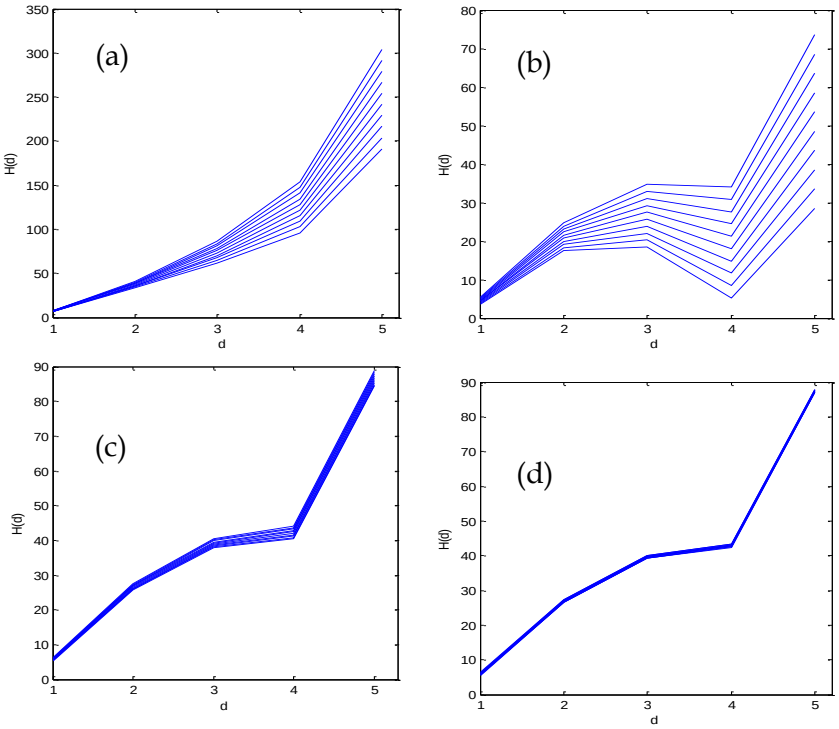

Fig 5 : Variation of Hardness with thickness for different a)P_2, b) P_3. c) P_4 .and d) P_5 values

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]

2. Nanocomposite hard Si-C-N coatings, A.S.Bhattacharyya, PhD Thesis, Jadavpur University, 2009 and corresponding references.

3. S.J. Bull · N. Moharrami, A Comparison of Nanoindentation Pile-up in Bulk Materials and Thin FilmsThin Solid Films 11/2014; 572:189-199. ·