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Improved Indentation Modulus Extrapolation for Stable Measurement of Indentation Modulus and Thickness of Superhard ta-C Coatings

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Coatings used in tribological applications often exhibit high hardness and stiffness to achieve a high wear resistance. One film characterization method frequently used is nanoindentation which allows the determination of indentation hardness and indentation modulus among other material properties. The indentation modulus describes the elastic surface behavior during indentation and for coating characterization is mostly relevant due to its indication of wear resistance. To obtain the true indentation modulus of a coating, the indentation modulus of the coated sample must be measured with varying load and then extrapolated to zero load. Current recommendation of the standard ISO 14577-4:2016 is a linear extrapolation, which fits poorly for non-linear curves. Such curves are commonly found for hard coatings on soft substrates, for example steel substrates with superhard tetrahedral amorphous carbon coating (ta□C).
In this study we present a new empirical fit model named "sigmoid". This fit model is compared to several existing fit models described in literature by means of goodness of fit and stability of fit, using nanoindentation measurements on ta-C coatings with wide ranges of indentation modulus and coating thickness. This is done by employing a user-independent and model agnostic fitting methodology.
It is shown that the sigmoid model outperforms all other models in both goodness of fit and stability of fit. Furthermore we demonstrate that the sigmoid model's fit parameter directly correlates with coating thickness and thus allows for a new approach of determining ta-C coating thickness from nanoindentation.

Keywords
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