
Thin films hardness: comparaison of models

Zineb Lakhlioui^{*†1,2}, Katir Ziouche¹, Didier Chicot², Alex Montagne³, Alberto Mejias⁴,
Thierry Coorevits⁵, and Francine Roudet²

¹Univ-Lille, CNRS, UMR 8520 - IEMN - Institut d'Electronique de Microélectronique et de Nanotechnologie, 59000 Lille, France – IEMN-CNRS 8520, Université des Sciences et Technologie de Lille, Cité Scientifique 59655 Villeneuve-d'Ascq, France. – France

²Univ-Lille, Laboratoire de Génie Civil et Géo-Environnement, LGCgE-ULR4515, 59000 Lille, France – Laboratoire de Genie Civil et géo-Environnement(LGCgE) – France

³Université Polytechnique Hauts-de-France, LAMIH UMR 8201 CNRS, Mont Houy, 59313 Valenciennes, France – LAMIH, UMR CNRS 8201, Université Polytechnique Hauts-de-France, Le Mont Houy, 59313, Valenciennes, France. – France

⁴JUNIA, Univ-Lille, Laboratoire de Génie Civil et Géo-Environnement, LGCgE-ULR4515, 59000 Lille, France – Junia – France

⁵Arts et Métiers ParisTech, MSMP EA-7350, 59800 Lille, France – École Nationale Supérieure d'Arts et Métiers (ENSAM) lille – France

Abstract

The characterization of thin films plays a crucial role in advancing micro-technologies, where material performance at micro and nano scales dictates the reliability of devices. This study aims to identify the most robust predictive model for mechanical properties of thin films, while defining its optimal conditions of application and understanding its limitations. By employing a combination of experimental nanoindentation and theoretical modeling, the study evaluates the predictive accuracy of widely used models, including those of Jönsson & Hogmark, Chicot & Lesage, Korsunsky, Puchi-Cabrera, and Burnett & Rickerby. Common point of these models is their linear function.

The objective is to determine the conditions under which these models yield reliable predictions, considering key parameters such as film thickness, residual stresses, and depth-to-thickness ratios (h/t). Limitations of conventional models under varying experimental conditions are explored, leading to some modifications across the majority of the studied models.

Additionally, a comparative analysis of thin films ranging from 1 to 1.7 μm , fabricated using PECVD (Low Pressure Chemical Vapor deposition) and LPCVD (Plasma Enhanced) techniques reveals differences in mechanical behavior due to variations in deposition methods, material composition, and structural uniformity. These findings emphasize the importance of integrating experimental data with theoretical models to refine the design and application of thin films for demanding environments. By defining the optimal application conditions and addressing model limitations, this study advances the development of thin films with enhanced durability and performance for micro-technological applications.

*Speaker

†Corresponding author: zineb.lakhlioui@univ-lille.fr