World Academy of Science, Engineering and Technology
International Journal of Mechanical and Industrial Engineering
Vol:11, No:03, 2017

Determination of Elasticity Constants of Isotropic Thin Films Using Impulse Excitation Technique

Authors : M. F. Slim, A. Alhussein, F. Sanchette, M. François

Abstract : Thin films are widely used in various applications to enhance the surface properties and characteristics of materials. They are used in many domains such as: biomedical, automotive, aeronautics, military, electronics and energy. Depending on the elaboration technique, the elastic behavior of thin films may be different from this of bulk materials. This dependence on the elaboration techniques and their parameters makes the control of the elasticity constants of coated components necessary. Our work is focused on the characterization of the elasticity constants of isotropic thin films by means of Impulse Excitation Techniques. The tests rely on the measurement of the sample resonance frequency before and after deposition. In this work, a finite element model was performed with ABAQUS software. This model was then compared with the analytical approaches used to determine the Young's and shear moduli. The best model to determine the film Young's modulus was identified and a relation allowing the determination of the shear modulus of thin films of any thickness was developed. In order to confirm the model experimentally, Tungsten films were deposited on glass substrates by DC magnetron sputtering of a 99.99% purity tungsten target. The choice of tungsten was done because it is well known that its elastic behavior at crystal scale is ideally isotropic. The macroscopic elasticity constants, Young's and shear moduli and Poisson's ratio of the deposited film were determined by means of Impulse Excitation Technique. The Young's modulus obtained from IET was compared with measurements by the nano-indentation technique. We did not observe any significant difference and the value is in accordance with the one reported in the literature. This work presents a new methodology on the determination of the elasticity constants of thin films using Impulse Excitation Technique. A formulation allowing the determination of the shear modulus of a coating, whatever the thickness, was developed and used to determine the macroscopic elasticity constants of tungsten films. The developed model was validated numerically and experimentally.

Keywords : characterization, coating, dynamical resonant method, Poisson's ratio, PVD, shear modulus, Young's modulus
Conference Title : ICEMA 2017 : International Conference on Experimental Mechanics and Applications
Conference Location : Madrid, Spain
Conference Dates : March 26-27, 2017