NEDEŠTRUKTÍVNE MERANIE YOUNGOVHO MODULU PRUŽNOSTI Al_2O_3 – (Y_2O_3) ZrO_2 POMOCOU DEFORMÁCIE OHYBOM

THE NON DESTRUCTIVE MEASUREMENT YOUNG´S ELASTICITY MODULUS Al_2O_3 – (Y_2O_3) ZrO_2 BY MEANS OF THE BEND

Jozef KRAJČOVIČ, Igor JANČUŠKA

Authors: ***Mgr. Jozef Krajčovič, PhD., RNDr. Igor Jančuška, PhD.***
Workplace: ***Institute of Materials, Department of Physics, Faculty of Materials Science and Technolog SUT***
Adress: ***J. Bottu 25, 917 24 Trnava, Slovak Republic***
Telephone: ***+421 33 5511033***
E-mail: ***jozef_krajcovic@stuba.sk,igor.jancuska@stuba.sk***

Abstract

Optické metódy sú vhodné predovšetkým na určenie mechanických parametrov krehkých tuhých materiálov. Napríklad Youngov modul pružnosti je možné určiť aj z priehybu nosníka metódou dvojexpozičnej holografickej interferometrie. Touto metódou sme získali interferogram, ktorý obsahuje sústavu svetlých a tmavých interferenčných prúžkov a z neho sme určili priehyb skúmaného predmetu v pôsobisku deformačnej sily. Skúmaný predmet bol eutektický kompozit tvaru štvorbokého hranola. Predkladaný príspevok obsahuje opis použitej metódy a vypočítané hodnoty Youngovho modulu pružnosti skúmaného eutektického kompozitu.

The optical methods are suitable primarily for the mechanical parameters determination of the fragile solid state materials. For example, we can determine the Young´s elasticity modulus from the girder bend by means of two-exposure laser holography interferometry method. We obtained interferogram by means of this method. Interferogram contains the system of the light and dark fringes and we determine from its the bend in the point of deformation force activity. Researched object was eutectic composite of the parallelepiped shape. This paper contains the used method description and calculated values of the researched eutectic composite Young´s elasticity modulus.

Key words

deformácia ohybom, interferencia svetla, eutektický kompozit, Youngov modul pružnosti

bend deformation, interference of the light , eutectic composit, Young`s elasticity modulus

Deformation of the direct girder

Direct longitudinal girder axis is deformed by deformation force activity. Deformed axis is called the bend girder line. We are interesting about bend y in case build-in girder with the single deformation force F, that actives perpendicular to girder axis in the point in distance l from the fixed end (Fig. 1). We determine the bend y from the Castigliano formula $y = \partial A/\partial F$, where A is the stress energy of the girder. This yields to formula for the Young´s elasticity modulus calculation

$$E = Fl^3/3Jy, \tag{1}$$

where E *is* Young´s elasticity modulus and J is the area momentum of inertia for the perpendicular cross-section of the girder respect to axis perpendicular to bend plane. [1]. We can determine the girder bend in the point of the force activity by means of several methods. We determine it by the holography interferometry method.

The girder bend determination by two-exposure holography interferometry method

Holography allows to obtain the information about the object on the holographic plate with high resolution, when we divide laser beam on two beams. First beam falls on the object. This beam is scattered by object and falls on the plate. The second beam is reflected by the mirror and falls on the same holographic plate. If path difference is smaller then coherence length, then both of the beams write the information about the object on the plate during the first exposure. If we do the second exposure the same plate when the object is deformed, then we get the holographic image of the object with the interference fringes on the plate after the development. Interference fringes give us the information about the girder deformation [2] (Fig. 2). We determine the value of the bend y from the number of dark fringes between fixed girder end and the point of the force activity. If the point of force activity is on (n+1)-th dark fringe from fixed end, then the bend of this point is $y = (2n+1)\lambda/4$. The area momentum of inertia for the rectangle girder cross-section is $J = ab^3/12$, where a, b are the sides of the rectangle and the force actives along the side b. Substituting in (1) we get formula for the Young´s elasticity modulus

$$E = 16Fl^3/(2n+1)\lambda ab^3 . \tag{2}$$

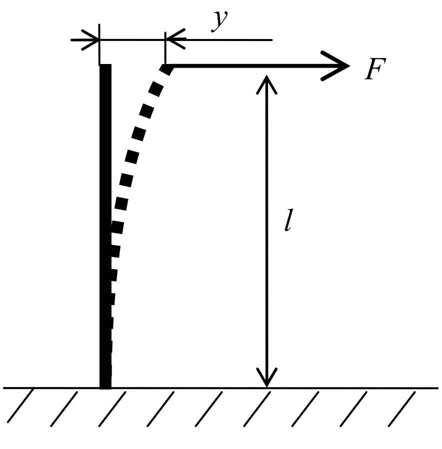

Fig.1. *Deformation of the build-in girder*

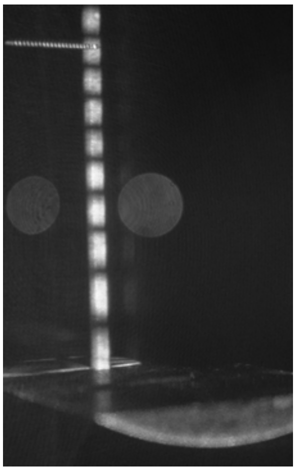

Fig. 2. *Digital picture of the holographic image with the interference fringes*

Discussion and conclusion

We used eutectic composite Al_2O_3 – (Y_2O_3) ZrO_2, that was prepared by the Stepanov/EFG method as the stick with 9 cm length and several mm width *a* and depth *b* . Chemical constitution was Al_2O_3 – 39,2 mol.% ZrO_2 – 2,2 mol.% Y_2O_3 . Growth speed was in interval (10 ÷ 80) mm/h. More detailed description of the preparation and microstructure is in the paper [3]. We measured Young´s elasticity modulus $E=(19.18\pm2.71)\text{x}10^{10}$Pa. This method is non-destructive, more, we achieved the required observed bend with the very small forces (30-80mN). Ability of the method to detect very small object deformations predestines this method for research of the materials with the small elastic deformation size. We will devote problem of the fixing sample in future, because the bad fixing causes the large deposit into the resulting error. Disadvantage of the method is we need constant and regular cross-section along the sample length. We can use the method in case the sample has complicated shape. In this case we can complete this method of the numeric model and to determine Young´s elasticity modulus and the Poisson number researched material by means of program ANSYS [4].

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