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J Material Sci Eng 2017, 6:2 (Suppl)
http://dx.doi.org/10.4172/2169-0022.C1.062

3rd International Conference on

Smart Materials & Structures

March 20-22, 2017 Orlando, USA

Large deformation of double cantilever beam fracture mechanics specimen with surface effects based on strain gradient theory

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Double cantilever beam fracture mechanics specimen is one of the most widely used test configurations to determine the mode I fracture toughness of homogenous, composite laminates and adhesively bonded materials. At micro and nano scale, according to the nonlocal theory of elasticity, the strain gradient and surface effects become prominent and must be considered. The 1D linear elastic constitutive equation can be written as σ=E (ε-$l^2\nabla^2\varepsilon$), where σ is the axial stress, ε is the axial strain, E is the Young's modulus, l is the material characteristic length. The objective of this research is to numerically investigate the size dependent-fracture behavior of DCB subjected to large deformation with simultaneous consideration of its root part. The governing equation of the large deformation Euler beam with surface and strain gradients effects is obtained as $EI_{eff}[d^2\varphi/ds^2-l^2d^4\varphi/ds^4]=-F\cos\varphi+H\varphi-H\varphi_{(a)}$, where F is the applied vertical concentrated force, effective bending rigidity is $EI_{eff}=Ebh^3/12+E^sh^3/6+E^sbh^2/2$, φ is the rotation angle of beam, $H=2\tau_o b$, b and h are width and height of the beam respectively. For illustration the material properties are taken to be E=1.44 GPa, G^s (effective shear modulus)=521.7 MPa, υ(poison ratio)=0.38, and l=17.6 μm. The value of surface elastic modulus (E^s) and surface stress (τ_o) are assumed to be zero and 0.2 μN/μm respectively. The static rotation of a cantilever beam, normalized by the classical result at the free end of the beam i.e., $Fa^2/(2EI)$ is presented in Fig. 1b. It may be seen that strain gradient beam with positive surface residual effect exhibit less stiff behavior in comparison with that of negative surface residual effects. Next, the strain energy release rate of double cantilever beam is plotted using $G_{(g,l)}=F\,(dY_{max}/bda)$, normalized with the classical result $G_o=12F^2a^2/(Eh^3b^2)$. Here G_g and G_l are the strain energy release rate of large deformation model with and without strain gradient effects respectively. As expected, the positive residual stress enhances the strain energy release rate Fig. 1c. The ratio (R) of the strain energy release rate contributed by the uncracked part to the cracked part of DCB is plotted for various a/h and h/l ratios in Fig.1d, it may fairly be concluded that R may not be neglected for smaller DCB even when the beam length to thickness ratio is higher. The influence of cumulative influence of strain gradients and surface effects on the large deformation of the cantilever beam is successfully studied to investigate the fracture of DCB. Beams with strain gradients and positive residual surface effects tend to exhibit less stiff behaviors. The root part of the DCB must not be ignored when the size of the beam is smaller than that of its material characteristic length.

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Non-destructive testing method for evaluating materials performances using slow positron facility

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A slow positron beam is been built at the Hebrew University of Jerusalem, the slow positron facility (SPOT). In Israel, the beam will introduce a new tool for both fundamental and applied research and also will be one of the first slow positron beams in the world which are industry oriented, hence the special design. Here we present the design process of the beam, where the leading goals are safety and high efficiency with a flexible choice of the positron source. The challenges in the design of a moderator unit, planned to utilize frozen gas in a conical geometry with replicable positron source, the pre-accelerator section and the full beam-line were addressed by various simulation programs. First positron transport measurements in SPOT are being held and a fully operating facility is expected within a year. We believe this tool will open new horizons for smart materials understanding and quality assurance while manufacturing them.

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