

37th National Conference on Theoretical and Applied Mechanics (37th NCTAM 2013) & The 1st International Conference on Mechanics (1st ICM)

Bending Stress Analysis of Laminated Foldable Touch Panel

Meng-Kao Yeh^{a,*}, Li-Yu Chang^a, Hsien-Chie Cheng^b, Pi-Hsien Wang^c

^aDepartment of Power Mechanical Engineering, National Tsing Hua University, 101, Sec. 2, Kuang Fu Road, Hsinchu 30013, Taiwan

^bDepartment of Aerospace and System Engineering, Feng Chia University, 100, Wen Hwa Road, Taichung 407, Taiwan

^cDisplay Technology Center, Industrial Technology Research Institute, 195, Sec. 4, Chung Hsing Road, Chutung 31040, Taiwan

Abstract

The touch panel technology has been developed in recent years, and the foldable touch panel is one of the newly attractive characteristics. This article focuses on the bending stress analysis of foldable touch panel, composed of plastic substrate PET, adhesive layer, plastic layer PI, organic layer and conductive layer ITO to form a seven-layer laminated structure. By applying four-point bending, the stress distribution of the touch panel under different radius of curvature was analyzed. The results show that the maximum von Mises stress occurred in the ITO layer and the maximum von Mises stress increased from 0.497 GPa to 1.242 GPa with decreasing radius of curvature. The region near the center of the touch panel has higher von Mises stress, and the relation between the radius of curvature and the maximum von Mises stress exhibits a non-linear feature.

© 2014 Elsevier Ltd. This is an open access article under the CC BY-NC-ND license

(<http://creativecommons.org/licenses/by-nc-nd/3.0/>).

Selection and peer-review under responsibility of the National Tsing Hua University, Department of Power Mechanical Engineering

Keywords: Foldable touch panel; four-point bending; radius of curvature; stress analysis

Nomenclature

κ	Curvature
ρ	Radius of curvature

* Corresponding author. Tel.: +886-3-574-2595; fax: +886-3-572-2840.

E-mail address: mkyeh@pme.nthu.edu.tw

1. Introduction

The touch panel used in some high-tech products, like smart phone, tablet personal computer has become an important technology in recent years and the foldable characteristics of touch panel has attracted more attentions. To be foldable, the touch panel becomes thinner, less weight and however vulnerable to fail. When the touch panel is folded, the conductive thin layer might failed due to the large deformation under bending.

For the transparent and conductivity features in touch panel, the Indium Tin Oxide (ITO) is selected as the conductive material. Sim et al. [1] studied the crack reduction method through bending experiment by adding the aluminium buffer layer into the PET/ITO laminated structure. Alzoubi et al. [2] found that the radius of curvature and the number of bending cycle are the two main factors resulting in the fatigue behaviour of the conductive layer ITO in bending test of flexible substrate. Cairns et al. [3] studied the mechanical property and the electrical failure of ITO with several substrates and found the crack number generated by bending would change with the deform shape of substrate. Oh et al. [4] used static bending and dynamic bending experiment to assess the failure mechanism of flexible substrate with ITO electrodes, the crack induced after experiment could affect the conductivity of ITO film. Lee and Lee [5] found that under compressive bending stress on polymer substrate, the cracks generated near the center of specimen and the crack number increased as the radius of curvature decreased. Sierras et al. [6] concluded that the combination of stress and corrosion by acrylic acid could cause ITO cracking at stresses lower than a quarter of those needed for failure without corrosion Yu et al. [7] added a silica buffer layer between plastic substrate PET and conductive layer ITO and found that after bending experiment the conductivity of ITO varied at different radius of curvature for both cases. Lan et al. [8] demonstrated that using a thermionic emission (TE) enhanced DC magnetron sputtering system to have ITO films deposited on polyethylene terephthalate (PET) substrates could improve electrical and optical properties under static and dynamic mechanical bending.

Leterrier et al. [9] showed that the internal stress and thickness of layer affected the failure mechanisms of flexible display by bending and fragmentation tests. Park et al. [10] studied the mechanical stability of externally deformed ITO films on polymer substrates. Gergo et al. [11] evaluated the bending method to test the flexible display and found the failure mode in flexible display. Chen et al. [12] assessed the flexibility and reliability of the flexible display in different use cases by failure analysis. Crawford et al. [13] used the flexible glass as substrate and ITO as the conductive layer in flexible touch panel to improve the life of panel by different circuit deployment. Li et al. [14] performed the thermal stress analysis of flexible panel with different temperature and humidity.

The bending behavior of the touch panel has been concerned in the most references mentioned-above. The bending stress analysis of the foldable touch panel are simulated in this study with different radius of curvature.

2. Finite element analysis

The finite element code ANSYS[®] [15] was used to analyze the stress distribution of foldable touch panel in the form of laminated structure under different radius of curvature. The finite element method is a method to change the continuum of infinite degree of freedom to a domain with finite degree of freedom by discretizing a solid structure into many elements. Each element has several nodes with finite degree of freedom. The system simultaneous algebraic equations can be derived by variational or weighted residual methods and the equations are solved by numerical analysis method [16-18]. The analysis procedure includes (1) defining the type of problem, (2) choosing the appropriate type of element, (3) building the analysis model with meshes, (4) applying the boundary conditions and loads, (5) solving the problem, and (6) display the results.

The element used in bending stress analysis of the foldable touch panel is Solid 45, which is a hexahedral element composed of eight nodes and each node has three degrees of freedom in x, y, and z directions. The touch panel with seven-layer laminated structure is composed of plastic substrate PET, adhesive layer, plastic layer Polyimide (PI), two organic layers and two conductive ITO layers. Fig. 1. shows the foldable touch panel with seven laminated layers. The thickness of each layer is shown in Table 1.

Download English Version:

<https://daneshyari.com/en/article/858233>

Download Persian Version:

<https://daneshyari.com/article/858233>

[Daneshyari.com](https://daneshyari.com)