

# 熱負荷による粘弾性三層積層体の反り変形挙動に関する実験と理論による検討

中村 省三<sup>\*</sup>, 末廣 啓伸<sup>\*\*</sup>, 三島 竜希<sup>\*\*\*</sup>, 勝山 陽介<sup>\*\*\*\*</sup>

## Experimental and Theoretical Study of Warpage Behavior for Viscoelastic Three Layer-Laminated Structure by Thermal Load

Shozo NAKAMURA<sup>\*</sup>, Hironobu SUEHIRO<sup>\*\*</sup>, Ryuki MISHIMA<sup>\*\*\*</sup>, and Yosuke KATSUYAMA<sup>\*\*\*\*</sup>

<sup>\*</sup> 広島工業大学大学院工学系研究科機械システム工学専攻 (〒731-5193 広島県広島市佐伯区三宅 2-1-1)

<sup>\*\*</sup> 広島工業大学大学院 [現:三菱電機エンジニアリング株式会社] (〒731-5193 広島県広島市佐伯区三宅 2-1-1)

<sup>\*\*\*</sup> 広島工業大学大学院 [現:航空自衛隊幹部候補生学校] (〒731-5193 広島県広島市佐伯区三宅 2-1-1)

<sup>\*\*\*\*</sup> 広島工業大学大学院 (〒731-5193 広島県広島市佐伯区三宅 2-1-1)

<sup>\*</sup> Major in Mechanical Systems Engineering, Graduate School of Science and Technology, Hiroshima Institute of Technology (2-1-1 Miyake, Saeki-ku, Hiroshima-shi, Hiroshima 731-5193)

<sup>\*\*</sup> Graduate School of Science and Technology, Hiroshima Institute of Technology [Now : Mitsubishi Electric Engineering Company Limited] (2-1-1 Miyake, Saeki-ku, Hiroshima-shi, Hiroshima 731-5193)

<sup>\*\*\*</sup> Graduate School of Science and Technology, Hiroshima Institute of Technology [Now : Air Officer Candidate School] (2-1-1 Miyake, Saeki-ku, Hiroshima-shi, Hiroshima 731-5193)

<sup>\*\*\*\*</sup> Graduate School of Science and Technology, Hiroshima Institute of Technology (2-1-1 Miyake, Saeki-ku, Hiroshima-shi, Hiroshima 731-5193)

**概要** 電子部品を簡易モデル化した鋼材/エポキシ樹脂/プリント配線板からなる粘弾性三層積層体を対象とし、これに加熱から冷却までの一連の熱負荷を加えた際に生ずる反り変形挙動を実験で求めた。次いで、これを有限要素法による解析および熱粘弾性応力・変形解析の結果と比較検討した。その結果、熱粘弾性応力・変形解析の結果は、有限要素法による解析結果に比べて実験値とよく一致した。また、この三層積層体の反り変形挙動は、粘弾性特性を示す樹脂のガラス転移温度、弾性係数および線膨張係数などの物性値と、その厚さ寸法に基づく曲げ剛性とは複雑に影響を及ぼし合っていることを明らかにした。

### Abstract

We experimentally examined the warpage behavior of a viscoelastic three-layer laminated structure consisting of steel/epoxy resin/printed board which modeled that of electronic devices caused simply by a series of thermal load from heating to cooling. We also calculated the warpage behavior using the finite element method and a thermo-viscoelastic stress/deformation analysis program based on linear viscoelastic theory which we have developed. Then, those experimental values were compared with those two theoretical values. From our results, the experimental warpage values are in good agreement with the thermo-viscoelastic analysis values, but are not in good agreement with the finite element analysis values. In addition, the warpage behavior of the viscoelastic three-layer laminated structure is influenced not only by the material properties such as glass transition temperature, modulus of longitudinal elasticity, and thermal expansion coefficient which depend on the temperature and flexural rigidity based on the thickness and width of the three-layer laminated structure.

**Key Words:** *Viscoelastic Analysis, Warpage, Finite Element Analysis, Thermal Load, Viscoelastic Laminated Structure*