Infrared Analysis of Thin Multilayered Polymer Film Using Cantilever Enhanced Photoacoustic Detector

Kaori Watanabe and Fumiko Hiwatashi
Systems Engineering Inc. www.systems-eng.co.jp info@systems-eng.co.jp

Introduction

Polymer thin film is used in...
- Structural material
- Electronic device
- Adhesive
- Paint and printing
- Biomaterial

Surface analysis
- XPS, SSIMS, SPM, XRD etc.
- Vibrational spectroscopy -> definitive molecular information

Novel PAS detector (GASERA; booth 555)
- Cantilever and laser interferometer based detector

This study
- Infrared PAS analysis of multilayered films
- Determination of accurate sampling depth of PAS with cantilever detector

Photoacoustic Spectroscopy (PAS)

Photoacoustic spectroscopy
1. Sample absorbs incident light
2. Absorbed energy partially transformed into heat (non-radiating relaxation)
3. Heat diffuses back to sample surface
4. Thermal expansion of surrounding gas detected

PAS advantage
- Highly sensitive
- Non-destructive
- Depth-profiling
  » Irregular shaped, small, or opaque sample etc.
  » THz, IR, NIR, UV-Vis etc.

Results and Discussion

1. PAS spectrum of multilayered film

Layered sheets of food wrap
PE, PVC, PVDC; 10 um each

PE 10 μm
PVDC 10 μm

1740 cm⁻¹ peak of PVC observed

Sampling depth > 10 μm ↔ PAS sampling depth μ > 7.6 μm

Photoacoustic signal observed beyond μ

2. PAS spectrum of multilayered film, various mirror velocity

Multilayered polyimide film
Kapton® 300F929

Estimation of accurate sampling depth Aμ (μ: factor)
- 1775 cm⁻¹ peak: Observed at 10 kHz, not observed at 20 kHz
  » 3.8A < 12.5 μm < 5.3A
- 1080 cm⁻¹ peak: Observed at 10 kHz, not observed at 20 kHz
  » 3.4A < 12.5 μm < 4.8A
- 605 cm⁻¹ peak: Observed at 20 kHz, not observed at 40 kHz
  » 4.6A < 12.5 μm < 6.4A

Estimated factor
2.6 < A < 2.7
i.e., A ≈ e

Heat generated at depth eμ can be detected
Generated heat decays to 1/e² at surface

Conclusion

Photoacoustic signal can be detected beyond PAS sampling depth μ.
Accurate sampling depth is estimated to be ~μ, where the generated signal decays to 1/e² upon reaching the sample surface.