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Deposition and electrostatic removal of gaseous organic contaminants on substrate surfaces

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Outline

- Introduction
- Experimental apparatus
- Results and Discussion
- Conclusion

Introduction

- FTIR, APIMS, IMS, XPS, TOF-SIMS, TD-GC-MS, and ATD/GC-MS techniques are costly and the analysis methods are rather complicated.
- Develop a convenient and cost-effective uv-spectroscopy measured low part per-million (ppb) level phthalate esters in cleanroom environments.
- Applying high electrostatic attraction force at a high voltage difference to remove the contaminant from conductive surfaces.
- The use of electrostatic repulsion prevent the adsorption of phthalate anion onto the wafer surfaces.

Experimental Apparatus

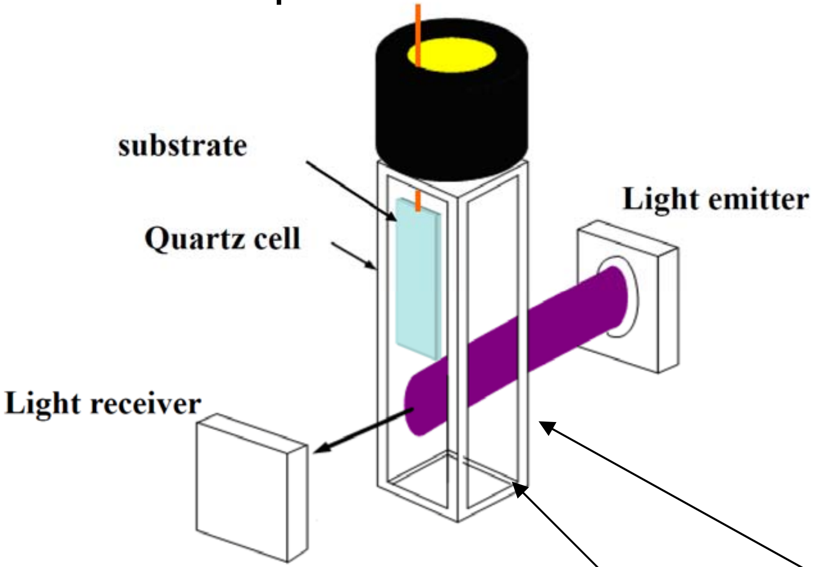
- Stock solution of Analytical-grade DBP (Acros Organics, USA)
- Concentration: 1,000 ppm (by volume), corresponding to 1,047 μg/cm3

- n-hexane (analytical-grade, Sigma-Aldrich, USA)
- Least interference solvant in UV spectrometric analysis

- Substrates of interest: Glass, Silicone Wafer, Quartz
- Dimensions: 20mm(L)x8mm(W).

Schematic diagram of experimental apparatus

1. Optical absorbance measurements and substrate adhesion study



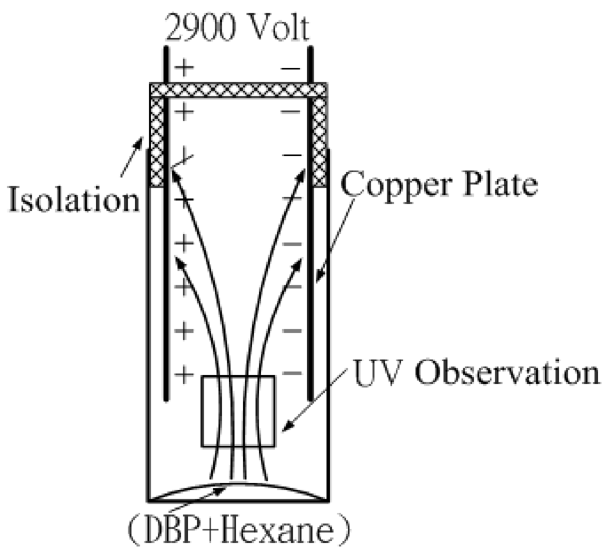
i. Quartz/Glass/Silicon (20x8)mm
ii. Evaporate DBP
iii. Flushed with hexane (2ml) to dissolve the surface-bound DBP.
iv. For blank control, experiment without placement

1) 10 μl of diluted DBP (0.05 - 500 ppmv) - 10 in for evaporation

2) Spectrophotometer transmits light through a quartz rectanglar cell having pathlength of 10mm.

Schematic diagram of experimental apparatus

2. Electrostatic force to remove DBP

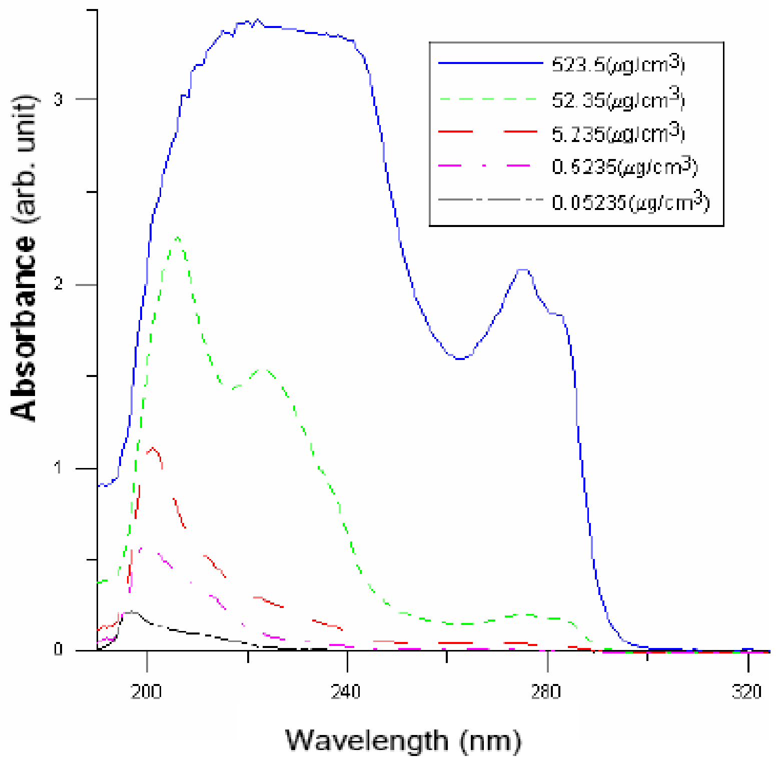


2 copper plates

Potential=2.9 kV to induce charging field 290 V/cm

UV-visible absorption spectra of n-hexane stabilized DBP solution at various DBP concentrations

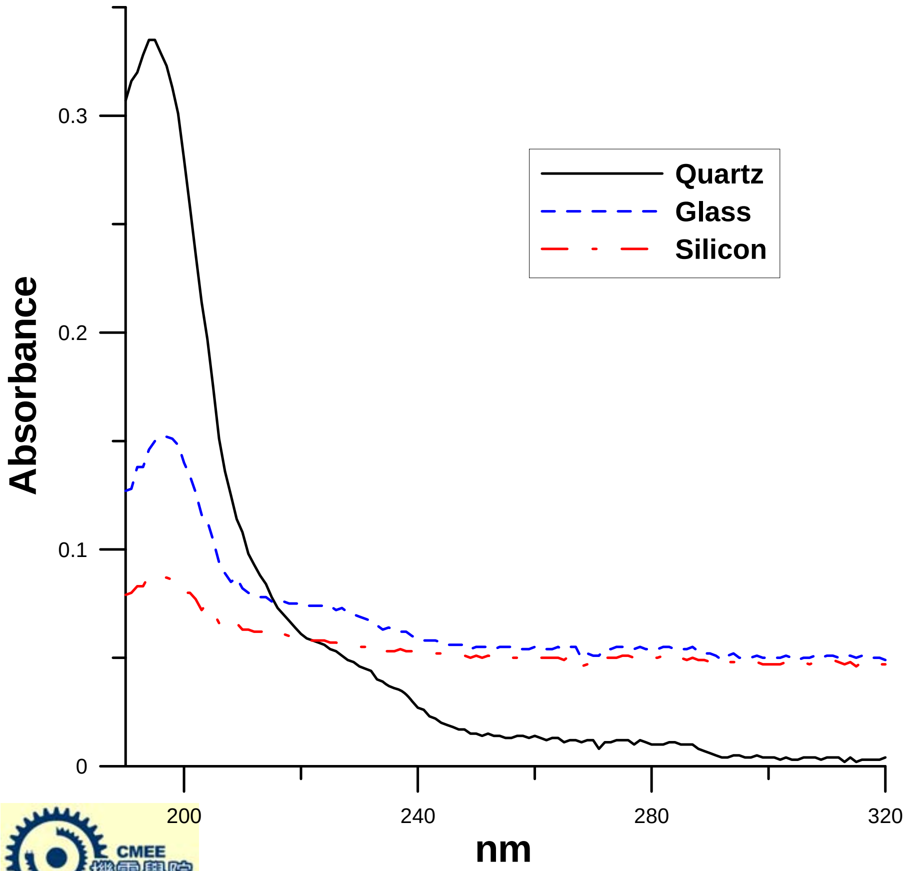
1. Optical Absorbance measurements



- These spectra have been adjusted to eliminate the absorbance interference from n-hexane.
- DBP exhibits broad absorption peaks
- Shift toward shorter wavelength at dilute concentrations, centering at:
  - 228 nm (523 g cm-3)
  - 208 nm (2.3 g cm-3),
  - 202 nm (23 g cm-3),
  - 200 nm (23 g cm-3), and
  - 198 nm (23 g cm-3).
- No any absorbance at visible range

Summary UV-visible absorption spectra of n-hexane stabilized DBP solution

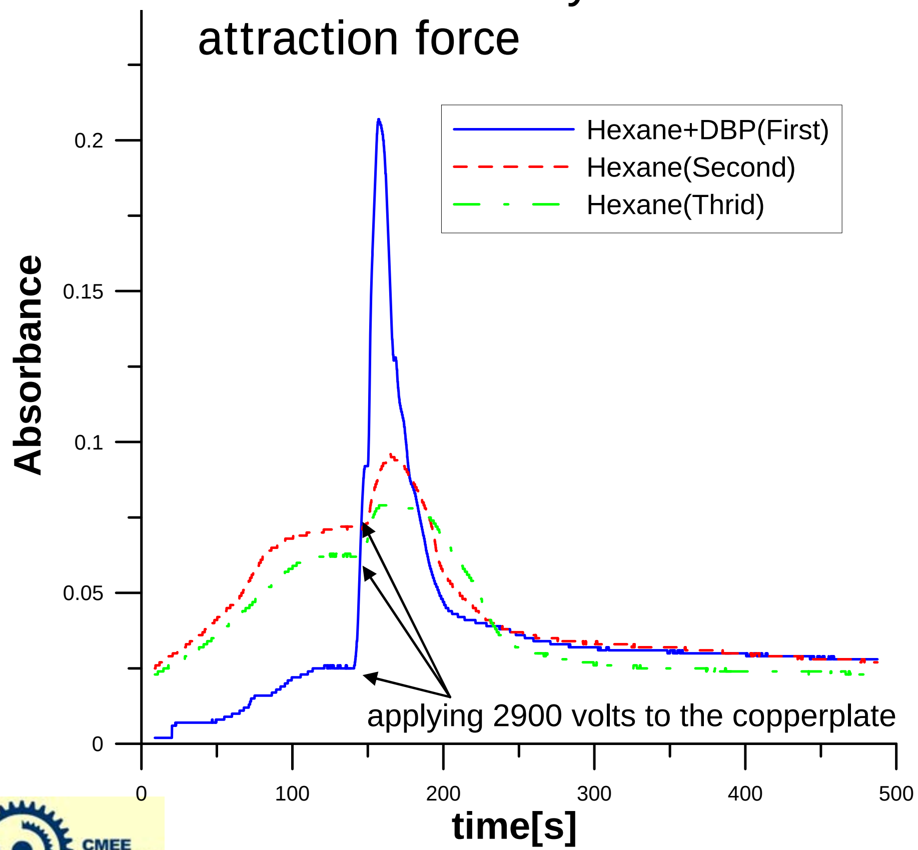
2. DBP adhesion tendency on different surfacesOptical Absorbance measurements



- Greatest tendency = quartz substrate, (adhesion mass of 0.247 μ g) (corresponding to a surface density of 0.154 g cm-2),
- glass (0.054 g cm-2), silicon (g cm-2).
- DBP molecule, composing of highly polar carbonyl groups, favors adhesion to surfaces with greater polarity.
- Quartz (SiO_2) substrate, which possesses greater electrophilicility than silicon and glass, was particularly prone to DBP adhesion.

Absorbance change after applied 2900 volts potential

3. DBP removal by electrostatic attraction force



- Absorbance reaches peak value ~170 s after activating the electric field.
- then, gradual declined as the charged aerosols moved further away from the window.
- Average drift velocity approx. 0.5 mm/s.
- 1 min amount of n-hexane was repeatedly added to the cell to further dissolve the residual DBP.
- The electric field caused the tailed hydrocarbon groups of the DBP molecules to depart from the quartz cell and attracted to the copper electrode.

Conclusion

- A simple and rapid technique using the UV spectrophotometry was established for quantifying the ambient and surface contamination by DBP.
- Quartz surface was more prone to DBP contamination than glass and Si surfaces.
- The surface adhesion of DBP could be effectively prevented by applying an electrical field in a confined space.
- The method can be applied to wafer storage and transport equipments to prevent wafer contamination from material outgassing.

Thank you

Q & A