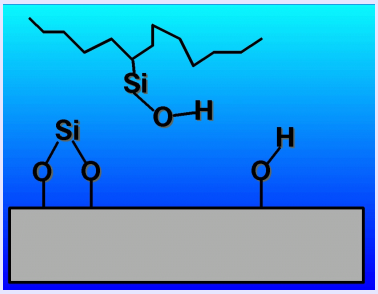
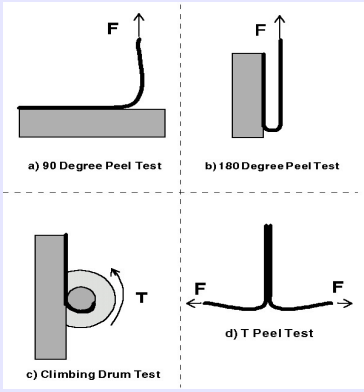


DETAILED DESCRIPTION SHORT COURSE ON CHEMISTRY, PHYSICS AND MECHANICS OF ADHESION SCIENCE



Adhesion plays an important role in many technologies and industries, viz., automotive, thin films, optics, coatings, paint and so on. Broadly speaking, the topic can be divided into two categories: film or coating /substrate combination, and adhesive joint. Films and coating are used for a variety of purposes and irrespective of their intended function, these must adhere adequately to the underlying substrate. So the need for understanding and controlling the factors affecting adhesion is quite patent. Also the durability of the bond (on exposure to process chemicals, moisture, corrosives, etc.) is of grave concern and importance. This course presents an overview of the chemistry, physics and mechanics of adhesion in regard to understanding fundamental adhesion mechanisms, how to improve and control them and the latest adhesion measurement techniques which are being used to evaluate the PRACTICAL ADHESION of coatings and laminate structures. Emphasis is given to methods which can be carried out in a manufacturing environment as well as in the lab and which give results that are directly relevant to the durability and performance of the structures under investigation. The effects of coating elastic properties and residual stress are considered as well as other external influences which affect durability under use conditions. Finally, an overview of the impact of atomic and molecular interactions on micrometer and nanometer sized structures (**M**icro-**E**lectro **M**echanical **S**ystems - **MEMS** and **N**ano **E**lectro **M**echanical **S**ystems- **NEMS**) will be explored. This leads to an elementary discussion of the most fundamental aspects of atomic and intermolecular behavior involving the concepts of quantum mechanics.

OVERVIEW

Audience: Scientists and professional staff in R&D, manufacturing, processing, quality control/reliability involved with adhesion aspects of coatings and adhesion sensitive applications.

Level: Beginner- Intermediate introduction/overview

Prerequisites: Elementary background In chemistry, physics or materials science.

Duration: 3 days

Course materials: complete set of lecture notes plus copy of the handbook, study supplement and reference guide **ADHESION MEASUREMENT METHODS: THEORY AND PRACTICE, (CRC PRESS, 2006)**

WHAT ARE YOU TAUGHT AND HOW YOU WILL BENEFIT FROM THIS COURSE:

After completing this course, you should be able to:

- Select the right surface cleaning technique
- Utilize the concept of acid-base interactions in improving adhesion
- Analyze the alternatives and select the optimum technique for improving adhesion, and hopefully, the durability.
- Know what are the latest developments and where to look for more information.
- Understand advantages and disadvantages of a range of adhesion measurement techniques.
- Acquire basic skills for addressing adhesion failure problems
- Analyze the alternatives and select the optimum technique for improving adhesion, and the durability.
- Know where help is available in emergency situations
- Learn how to select best measurement technique for a given application.

INSTRUCTORS AND CONTACT INFORMATION

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TOPICS TO BE COVERED

SURFACE CONTAMINATION AND CLEANING

- Various Cleaning Techniques
- Characterization of Cleanliness
- Importance of Cleanliness in Adhesion
- Storage of Clean Parts

THEORIES OR MECHANISMS OF ADHESION

- Various theories:
  - Mechanical
  - Surface
  - Energetics
  - Diffusion
  - Electrostatic
  - Chemical:
    - Acid-Base, and Weak Boundary Layer) with their Relative Validity and Usefulness.
  - Special Consideration of Acid-Base Concepts in Adhesion

CONTACT ANGLE, WETTABILITY AND ADHESION

-
- Contact Angle Measurement and Factors Affecting it
- Determination of Surface Free Energy of Polymers
- Relevance of Wettability and Surface Energetics in Adhesion

INVESTIGATION OF INTERFACIAL INTERACTIONS

- Application of ESCA in Unraveling Events at an Interface

SURFACE MODIFICATION TECHNIQUES AND OTHER WAYS TO IMPROVE ADHESION OF ORGANIC COATINGS

- Various Surface Modification Techniques
- (e.g., Plasma, Flame, Corona, Laser, UV, Ozone, Wet)
- Other Ways to Improve Adhesion
- Factors Affecting Adhesion of Organic Coatings
- Stresses in Coatings and Their Relevance to Adhesion

SILANES AND OTHER ADHESION PROMOTERS

- Various Aspects of Silane Adhesion Promoters; How to Apply Them and Where to Apply Them?
- Examples of Adhesion
- Improvement by Use of Silanes
- Non-Silane Adhesion Promoters

ADHESION ASPECTS OF THIN FILMS

1. Various Mechanisms of Adhesion of Thin Films
2. Factors Affecting Adhesion of Thin Films and Ways to Improve Adhesion (Note: Metallized Plastics and Cases of Other Thin Films on a Variety of Substrates will be Discussed)

ADHESION MEASUREMENT OF FILMS AND COATINGS

- Concept of Practical Adhesion
- Various Techniques (Ranging from Simple to Sophisticated) for Measuring Adhesion with Their Potentialities and Limitations
- Basics of adhesion measurement:
  a. Qualitative methods
  b. Semi-quantitative methods
  c. Fully quantitative methods
- Role of residual stress and material mechanical properties on adhesion:
  a. Effect of coating and substrate elastic properties
  b. Effect of residual stress
- Problem of setting adhesion requirements for coating applications:
  a. What is a sufficient level of adhesion strength?
  b. Avoid over-specifying adhesion requirements to the detriment of other product requirements.
  c. Problem of long-term environmental degradation.
- Adhesion measurement at atomic and molecular level (fundamental adhesion):
  a. Surface force apparatus
  b. Atomic force microscope
  c. Hamaker theory
  d. Contact angle behavior
- General Applications:
  - Setting quality control specifications
  - Provide data base for product engineering design work
  - Support new product research and development
  - Identify and eliminate potential failure modes early in development cycle
  - Enable rapid effective response to unforseen failure mechanisms

DURABILITY OF ADHESIVE JOINTS PART ONE: OVERVIEW OF TEST METHODS

1. Two Aspects of Adhesive Action

- a. Interfacial bonding between adhesives and adherends
- b. Bulk thermal-mechanical performance of adhesives

2. Durability of Adhesive Joints

- a. Stress and Deformation in Material Bodies, a quick overview
- b. Strength of Materials Theory (SOM)
- c. Fracture Mechanics

3. **Direct Measurement of Joint strength**

- a. Lap shear test
- b. Double cantilever beam test
- c. Four point bend test

4. **Measuring Adhesive Thermal-Mechanical Properties**

- a. Elastic properties
- b. Viscoelastic properties
  - i. Creep behavior
  - ii. Concept of time-temperature superposition

5. **Role of Residual Stress**

- a. Cantilevered beam methods
- b. Ultrasonics
- c. Photoelasticity
- d. Strain relief methods

6. **Nondestructive Inspection**

- a. Xray
- b. Thermography
- c. Shearography
- d. Ultrasonics

PART TWO: DETAILED LOOK AT SPECIFIC TESTS AND CASE STUDIES

1. A Closer Look at Interfacial Adhesion Through the Peel Test

- a. Peel testing on a shoe string

2. **The Peel Test in the Development Lab and Manufacturing Line**

- a. Ranking effectiveness of adhesion promoters
- b. Evaluating the effect of manufacturing procedures on bond durability
- c. Developing improved process steps

3. **A Closer Look at The Thermal-Mechanical Properties of Polymers**

- a. Common Test methods
  - i. Dynamic mechanical experiments
  - ii. Determination of glass transition, T_g
  - iii. Relaxation processes below T_g
- b. Case Study on rubber modified epoxy structural adhesives
  - i. Time-temperature superposition for epoxies
  - ii. Variation of fracture toughness with loading rate and temperature

4. **Putting it All Together: A Guide to the Evaluation and Prediction of Bond Durability**

- a. Structures that survive in the long term are in a state of unconditional stability
- b. Stability maps: An engineering tool for putting it all together.
- c. Case study: Adhering pins to a multi-chip module:
  - i. Pathology of pin failure, outline of the problem
  - ii. Modeling virtual crack propagation
  - iii. Creating a stability map