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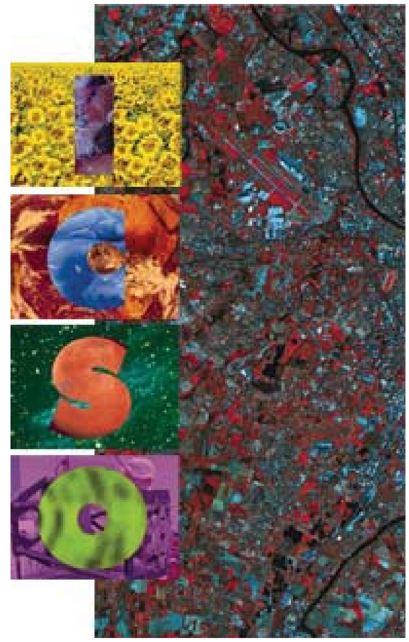

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NON DESTRUCTIVE EXAMINATION OF INTERFACE OF MOLECULAR ASSEMBLY

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RESUME -
Dans le but de caractériser les assemblages moléculaires on peut envisager des essais mécaniques et / ou des interactions ondes / interfaces.
L'inconvénient des essais mécaniques tient au fait qu'ils peuvent engendrer des défauts et / ou être destructifs.
L'utilisation d'interactions entre ondes et interfaces est par contre non destructive. Mais quels types d'ondes utiliser ? Les ondes électromagnétiques dans le domaine du visible sont tributaires de l'atténuation dans le matériau à traverser, l'infrarouge va être aussi sensible aux épaisseurs des pièces, les rayons X vont avoir une longueur d'ondes trop courte pour "détecter" l'interface.
L'approche proposée ci-dessous retient les ondes acoustiques pour caractériser l'interface des assemblages moléculaires.
La propagation des ondes acoustiques est en effet très sensible aux variations de liaisons aux interfaces, que les ondes soient réfléchies ou transmises. Pour améliorer la sensibilité et la résolution, on a réduit la longueur d'onde en utilisant la microscopie acoustique de bande passante (1 MhZ / 400 MhZ).
Après la description de la méthode, des résultats d'application sont présentés. Les différentes applications de la microscopie acoustique aux assemblages moléculaires et aux matériaux concernés sont proposées.

ABSTRACT -
Molecular assembly interfaces can be characterised by mechanical testing and/or the interaction between waves and the interface.
The disadvantage of the mechanical approach is that new defects may be produced at the interface, or existing defects may be destroyed.
Using the interaction between waves and the interface is a non-destructive approach. But what kind of waves should be used? Electromagnetic waves in the visible range depend on wave attenuation in the material, infrared waves also depend on the thickness and X-ray waves have a too short a wave length to detect interface defects.
In this article, the use of acoustic waves is proposed for non-destructive examination of molecular assembly interfaces.
Acoustic wave propagation is very sensitive to variations in interface characteristics depending on whether the waves are reflected or transmitted. To improve the sensitivity and resolution of this technique, small wave lengths have been used with a scanning acoustic microscope (S.A.M.) with a band width from 1MHz to 400 MHz.
After a short description of the principle of the method, results are given for different types of components. Different applications of acoustic microscopy are proposed for non-destructive examination of interfaces and defect detection in materials.

1. SCANNING ACOUSTIC MICROSCOPY (S.A.M.) [1]

In this technique a piezoelectric transducer emitting and receiving ultrasonic energy pulses scans across the surface of a component immersed in a water bath. The ultrasonic sound beam is focused using lenses (hence the term "microscopy") at different levels within the component in order to image a particular layer. The resulting image is referred to as a C-Scan. Scanning acoustic microscopes have two distincts operating modes from which images can be generated.

The reflective mode or pulse echo mode is a single-sided technique using one transducer to send a pulse out and receive the return echo from the component being tested. Amplitude, phase change and depth information are extracted from the echo for imaging the part non-destructively.

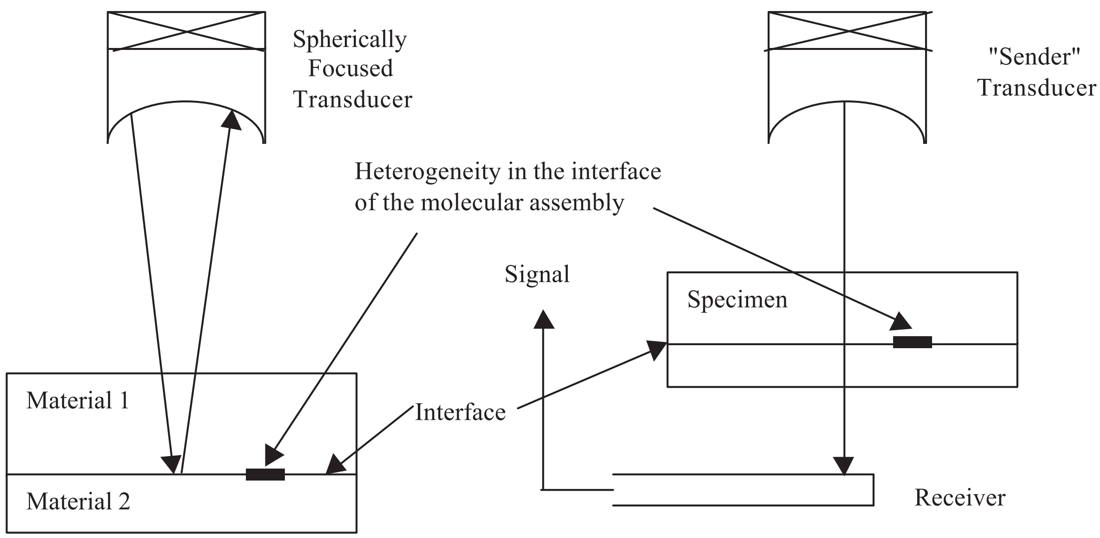

Fig. 1 : Pulse echo schematic **Fig. 2** : Through transmission schematic

Through-transmission is a dual-sided technique which uses two transducers, one to send the ultrasonic pulse and the other transducer to receive it. Typically only amplitude, or the amount of sound transmitted, is measured in order to create an image of the component. Although it is similar to X-ray examination in concept, the capability of this test is very different.

Using sound to penetrate materials and to characterise the interface is not commonplace [2]. The following equation illustrates this with: $R = \frac{Z2 - Z1}{Z2 + Z1}$ where $Zi = \rho i v i$ with ρi density and Vi wave velocity.

This equation is always used in the acoustic field when discussing the ability of sound to travel into the device and return to the receiver. R is the reflected pressure at zero angle of incidence, Z1 is the acoustic impedance of the material the sound is leaving and Z2 is the acoustic impedance of the material the sound is entering. In most applications relating to the microelectronics industry, the user is looking at the bond integrity between different materials. In case of heterogeneities at the interface of the molecular assembly the difference between Z1 and Z2 will change and the heterogeneity will thus be detected.

Acoustic tomography can be performed [3]. The depth resolution depends on wave length.

2. CHARACTERISTICS OF THE EQUIPMENT

Scanning area : Adaptable
Linear Encoder resolution : 1µm
Step of scanning : 1µm mini
Band width : up to 400 MhZ
Analogic / Digital conversion rate : 1 GhZ (1ns step)
Tomography capabilities
Reference of equipment : SONIX S.A.M. – UHR 2000

Fig. 3 : Scanning Acoustic Microscope : SONIX S.A.M. – UHR 2000

3. EXAMPLES OF RESULTS

3.1. Specimens diameters : 50 mm
Total thickness : 20 mm
Material : optical glace
Optical examination : No defect have been detected
Similar results are obtained with SiC materials in which porosities or inclusions resulting from the sintering technique have been detected. In such material, it is not possible to make an optical examination of the interfaces.

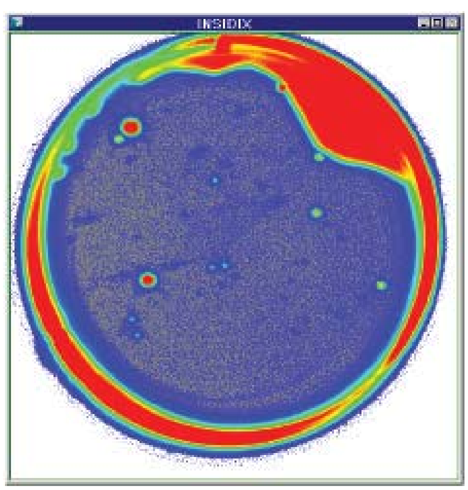

Fig. 4a

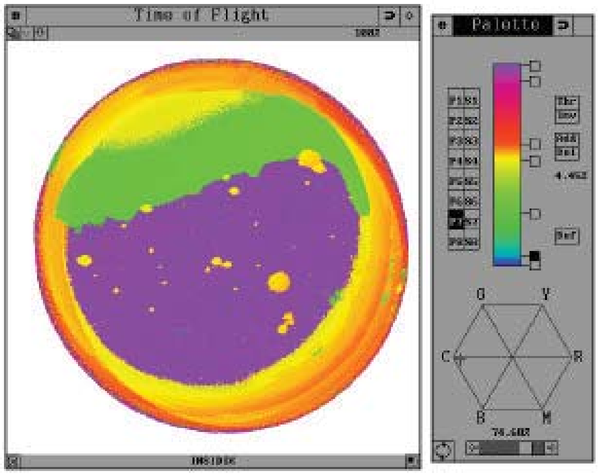

Fig. 4b

Fig. 4 : Images of interface response using Scanning Acoustic Microscopy

Different information can be used for image representation: the reflection amplitude, Fig. 4a, or the travel time from the surface, Fig. 4b, which can be used to distinguish between different kinds of defects in relation to their position at the interface.

3.2. Silicon / Silicon interface
Specimen diameter : 200 mm
Total thickness : 2 mm
Materials : Si
Results are given in Fig. 5: Small defects of 15 µm width at the interface have been detected. Regardless of their size, these defects cannot be detected by infrared techniques.

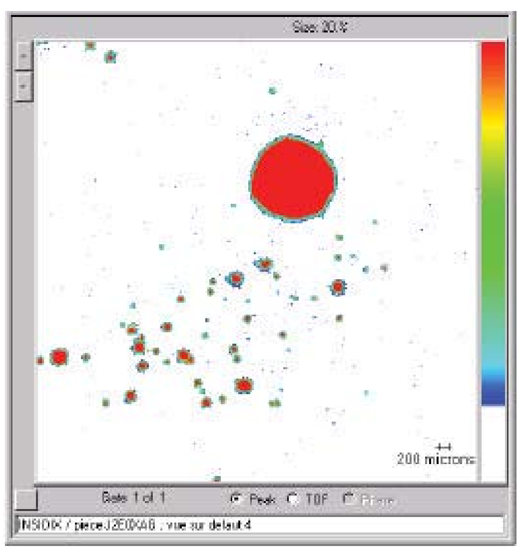

Fig. 5 : Image of interface response using Scanning Acoustic Microscopy
on Si/Si molecular interface assembly

4. S.A.M. APPLICATION FOR MOLECULAR ASSEMBLY

- Detection of variations in acoustic reflection at the interface
- Detection and selection of different kinds of defects
- Defects in sintered materials such as SiC
- Interface parallelism and thickness
- Multi-interface acoustic tomography
- Thickness measurement
- Kinetics of interface deterioration under mechanical or thermal stress

5. CONCLUSION

A non-destructive technique, acoustic microscopy, has been used for the examination of molecular assembly interfaces.

Defects have been detected in opaque materials such as SiC. Small defects of 15 µm width can be detected in Si/Si assemblies that other techniques cannot detect.

Scanning Acoustic microscopy (S.A.M.) can be used for process qualification, quality control, correlation between mechanical results and defects. The kinetics of defect propagation at the interface could be archived

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