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Combined Use of Oscillating Means and Ellipsometry to Determine Uncorrelated Effective Thickness and Optical Constants of Material Deposited From a Fluid

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(54) **COMBINED USE OF OSCILLATING MEANS AND ELLIPSOMETRY TO DETERMINE UNCORRELATED EFFECTIVE THICKNESS AND OPTICAL CONSTANTS OF MATERIAL DEPOSITED FROM A FLUID**

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Related U.S. Application Data

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(60) Provisional application No. 60/437,024, filed on Dec. 31, 2002.

(51) **Int. Cl.**
G01J 4/00 (2006.01)

(52) **U.S. Cl.** **356/369**; 356/630

(58) **Field of Classification Search** .... None
See application file for complete search history.

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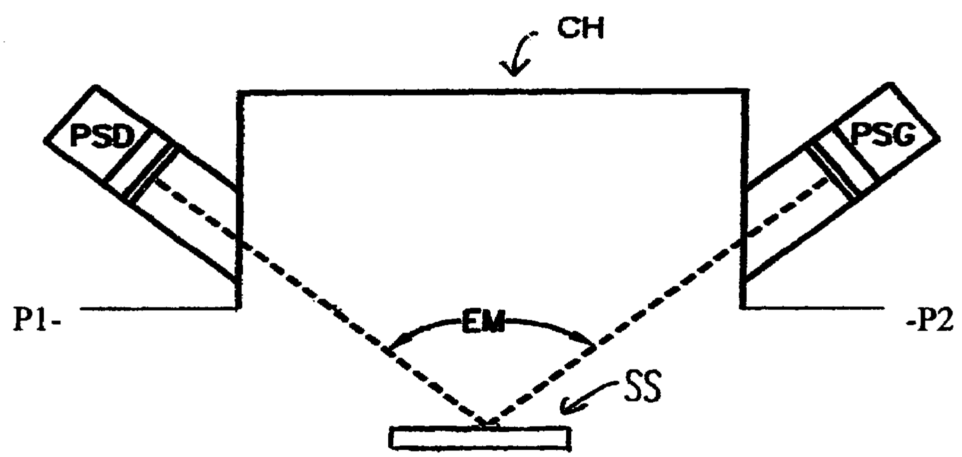
Primary Examiner—Michael P. Stafira
(74) *Attorney, Agent, or Firm*—James D. Welch

(57) **ABSTRACT**

A combined ellipsometer and oscillator system applied to a chamber for containing fluid, and method of decorrelated determination of thickness and optical constants of depostable materials present in a fluid. In use the ellipsometer determines the product of thickness and optical constant, and the oscillator system changes frequency of oscillation proportional to the thickness of material deposited upon a surface of an element therein.

11 Claims, 2 Drawing Sheets



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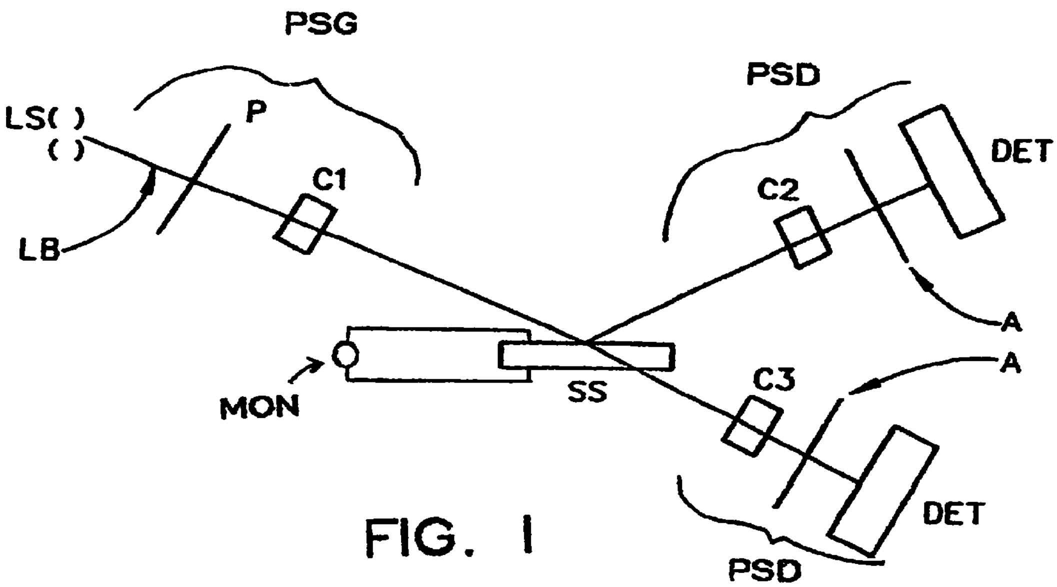

FIG. 1

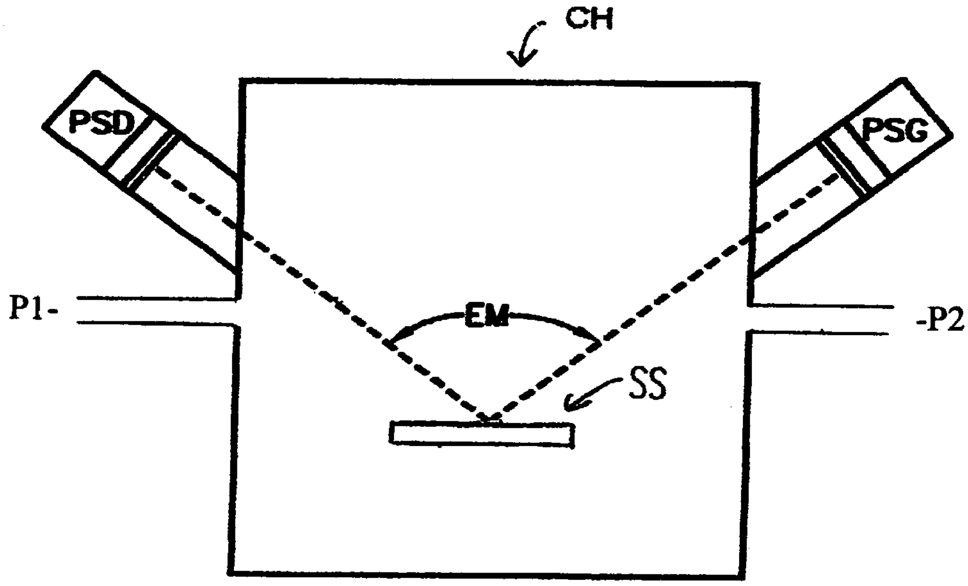

FIG. 2

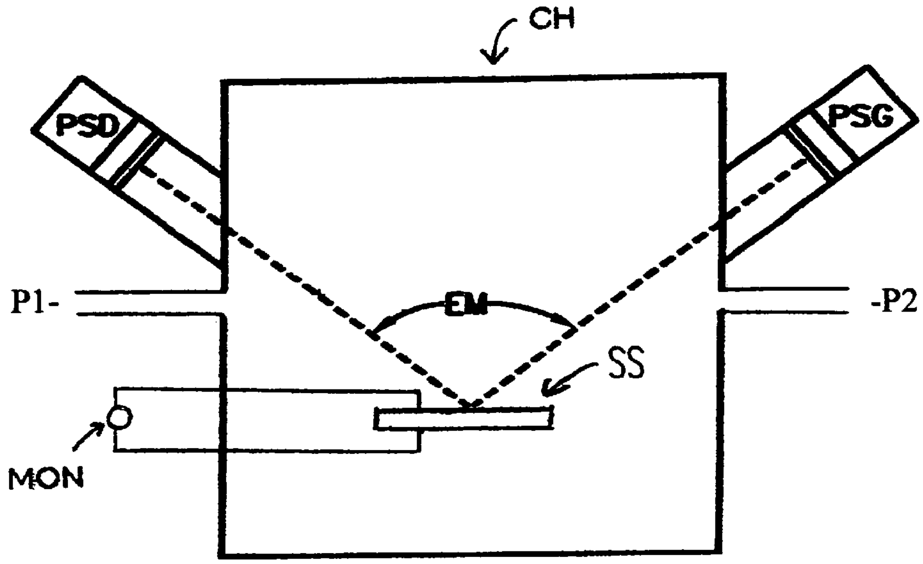

FIG. 3

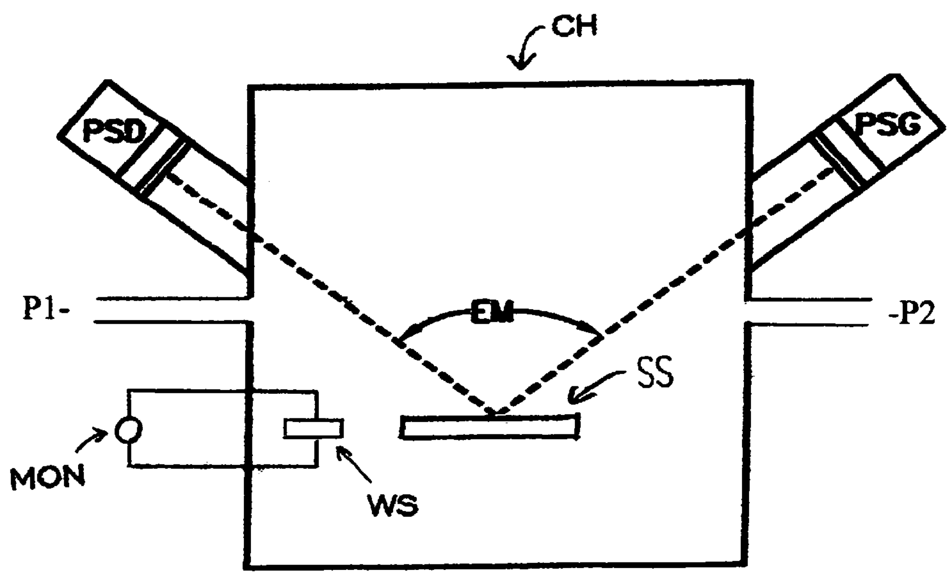

FIG. 4

COMBINED USE OF OSCILLATING MEANS AND ELLIPSOMETRY TO DETERMINE UNCORRELATED EFFECTIVE THICKNESS AND OPTICAL CONSTANTS OF MATERIAL DEPOSITED FROM A FLUID

This Application is a CIP of Allowed application Ser. No. 10/746,924 Filed Dec. 25, 2003 now U.S. Pat. No. 7,030, 982, and Claims Benefit of Provisional Application 60/437, 024 Filed Dec. 31, 2002.

TECHNICAL AREA

The disclosed invention relates to systems and methods for simultaneously determining thickness and refractive indicies or densities of materials, and more specifically to a combined ellipsometer and oscillating means system and method, wherein said oscillating means changes frequency of oscillation when material is deposited from a fluid, thereupon.

BACKGROUND

It is well known to use ellipsometry to determine thickness and optical constants of thin film materials. It is also known that ellipsometry provides a correlated product of thickness and refractive index. One known approach to breaking the correlation is to investigate two samples which have different thicknesses of the same material thereupon, and simultaneously perform regression of mathematical models for the two samples onto ellipsometric data obtained from each. The presently disclosed invention proposes a different approach to breaking the identified correlation involving gaining insight to the "effective thickness", (ie. thickness per se. as modified by surface coverage, roughness and/or porosity etc.) of a material caused to accumulate on the surface of an oscillating means, and using said insight in evaluating the product of the "effective" thickness and optical constants via ellipsometric techniques. That is, if an effective thickness of a material is determined by other techniques, and the product of said effective thickness and refractive index of a material is determined by ellipsometric techniques, then the refractive index can be determined by a simple division.

A Search for relevant reference material has provided Patents:

U.S. Pat. No. 6,125,687 to McClelland et al. which describe a system for determining outgassing comprising a microbalance.

U.S. Pat. No. 4,561,286 to Sekler et al. which disclosed a piezoelectric detector.

U.S. Pat. No. 4,735,081 to Luoma et al. which discloses a detector for detecting vapors is gaseous fluids comprising a crystal oscillator.

Articles which were identified are:

"Surace Specific Kinetics of Lipid Vesicle Adsorbtion Measured With a Quartz Microbalance", Keller et al., Biophysical Journal, Vol. 75, (1998). This article discusses simultaneous frequency and dissipation measurements performed on QCM provide an efficient approach to measuring the kinetics of lipid vesicle adsorbtion and characterizing adsorbed layers.

"Simultaneous Monitoring of Protein Adsorbtion at the Solid-Liquid Interface From Sessile Solution Droplets by Ellipsometry and Axisymmetric Drop Shape Analysis by Profile", Noordmans et al., Colloids and Surfaces B: Biointerfaces 15, (1999). This article discusses combination of aqueous phase atomic force microscopy, ellipsometry and axisymmetric drop shape analysis by profile (ADSA-P).

"Characterization of PNA and DNA Immobilization and Subsequent Hybridization with DNA Using Acoustic Shear-Wave Attenuation Measurements", Hook et al., Langmuir 17, (2001). This article discusses combined use of a quartz microbalance and dissipation monitoring can characterize the bound state of single-stranded peptide nucleic acid (PNA) and deoxyribose nucleic acid (DNA).

"Relaxation Dynamics in Ultrathin Polymer Films", Forrest et al., Physical Review E, Vol. 58, No. 2, (1998). This paper describes combined application of Photon Correlation Spectroscopy and Quartz Balance Microbalance.

"Structural Changes in Hemoglobin During Adsorbtion to Solid Surfaces: Effects of Ph, Ionic Strentth, and Ligand Binding", Hook et al., Proc. Natl. Acad. Sci., Vol. 95, (1998). This article describes application of a Quartz Microbalance technique to follow Hb adsorption onto a surface. The Quartz Crystal Microbalance (QCM) system is described in this article as comprising a disk shaped, AT-cut Piezoelectric Quartz Crystal with metal electrodes deposited on two faces. In use the crystal is excited to oscillation in the thickness shear mode at its fundamental resonance frequency (f), by applying a RF Voltage across the electrodes near the resonant frequency. A small mass (ΔM) added to the electrode induces a decrease in the resonant frequency (Δf) which is proportional to the (Δm), providing that the mass is evenly distributed, does not slip on the electrode and is sufficiently rigid and/or thin to have negligible internal friction. An equation is given which provides a quantitative descriptions:

$$\Delta M=(C\Delta f)/n$$

where C (=17.7 ng cm^{-2} Hz^{-1} at f=5 MHz), is the mass-sensitivity constant and n(=1, 3, . . .) is the overtone number.

Also disclosed are materials from "Q-SENSE" which disclose Quartz Micro-Balance systems:

"Q-SENSE D300";

"QCM-D Applications, Biosurfaces in Depth";

"Investigating the Sticking Power of Blue Mussels".

Finally, the methodology of ellipsometry is described in many references such as U.S. Pat. No. 5,373,359 to Woollam et al., U.S. Pat. No. 5,872,630 to Johs et al., U.S. Pat. No. 5,963,327 to He et al., U.S. Pat. No. 6,353,477 to Johs et al., U.S. Pat. No. 6,034,777 to Johs et al., U.S. Pat. No. 6,456,376 to Liphardt et al., U.S. Pat. No. 5,706,212 to Thompson et al. and U.S. Pat. No. 5,666,201 to Johs et al. An article by Johs titled "Regression Claibration Method for Rotating Element Ellipsometer", Thin Film Solids 234 (1993); an Article by Collins titled "Automatic Rotating Element Ellipsometers: Calibration, Operation and Real-time Applications", Rev. Sci. Instrum. 61 (8) (1990), and a book by Azzam & Bashara titled "Ellipsometry and Polarized Light", North-Holland (1977) is also disclosed.

Briefly, ellipsometry causes a polarized beam of electromagentic radiation to interact with a sample surface and then enter a detector. Changes in polarization state in the beam caused by the sample are represented by ellipsometric PSI and DELTA which are identified by:

$$\rho=rp/rs=\mathrm{Tan}(\Psi)\exp(i\Delta)$$

where r_p and r_s are orthogonal components of the beam perpendicular and parallel to, respectively, the sample surface.

A mathematical model of the Sample is proposed and a regression procedure applied to convert the PSI and DELTA values to Sample representing values such as correlated thickness and optical constant values corresponding to various wavelengths and angles of incidence of the beam to the sample surface.

The forgoing references are incorporated by reference herein.

Even in view of known Prior Art, need remains for a system and method to combine Spectroscopic Ellipsometry and Quartz Microbalance techniques to the end of providing uncorrelated determination of both thickness and optical constants of deposited materials.

DISCLOSURE OF THE INVENTION

The disclosed invention comprises a system which comprises a chamber having port means for entering and exiting fluid which contains depositable material. Said chamber comprises therewithin an oscillating means having a surface area, said oscillating means being a part of an oscillator circuit such that it is caused to physically vibrate or support resonant or non-resonant acoustic waves when electrical potential is applied thereto. Said chamber further has affixed thereto a polarization state generator and polarization state detector. In use material is allowed to deposit onto the oscillating means surface area from fluid containing depositable material which is entered thereinto via said port means; and sequentially or simultaneously:

- electrical potential is applied to said oscillating means and change in the frequency of oscillation is monitored during said deposition; and
- a beam of electromagentic radiation provided by said polarization state generator is caused to interact with said material being deposited and then enter said polarization state detector.

Said system can further comprise a sample present in said chamber which sample has a surface area upon which said material being deposited onto said oscillating means surface area also deposites. The beam of electromagentic radiation provided by said polarization state generator can then be caused to interact with at least one selection from the group consisting of:

said material deposited on said oscillating means surface area; and

said material deposited on said sample surface area.

The disclosed invention further applies said system in a method of determining an effective thickness of a material caused to deposit from a fluid onto a surface, in uncorrelated combination with optical constants of said material caused to deposit on said surface or another surface.

A present invention method of determining an effective thickness of a material caused to deposit on a surface, in uncorrelated combination with determination of optical constants of said material, comprises the steps of:

a1) providing an oscillating means having a surface area, said oscillating means being a part of an oscillator circuit such that it is caused to physically vibrate or support resonant or non-resonant acoustic waves when electrical potential is applied thereto;

a2) providing a chamber into which a fluid which contains a depositable material is caused to be present as well as said oscillating means.

Said method proceeds with simultaneously or sequentially:

b1) allowing said depositable material to deposit onto the surface of said oscillating means before and/or while it is caused to vibrate and/or support resonant or non-resonant acoustic waves at a frequency; and

b2) causing a beam of electromagnetic radiation to interact with said surface area of said oscillating means and

c) in functional conjunction with step b) determining a relationship between a change in frequency of said oscillating means vs. effective thickness material deposited thereupon, and providing a mathematical model of the oscillating means and deposited material system which includes said effective thickness, and optical constants of the deposited material;

d) analyzing change in frequency of said oscillating means to determine effective thickness of said deposited material, and performing regression of the data detector provided data onto said mathematical model to determine optical constants of said deposited material in view of said determined effective thickness.

Said method can involve the beam of electromagnetic radiation being caused to interact with said surface area of said oscillating means, upon which material is deposited, and then enter a data detector is provided by an ellipsometer or polarimeter system which comprises, in a polarization state generator, a source of electromagnetic radiation and polarizing means and in which said data detector is part of a polarization state detector which further comprises analyzer means.

Said method can involve use of a quartz crystal as the oscillating means.

Said method can provide that the thickness is characterized by at least one selection from the group consisting of:

- thickness per se;
- surface coverage;
- roughness; and
- porosity.

A modified method of determining uncorrelated thickness and optical constants of a deposited material comprising determining an effective thickness of a material in uncorrelated combination with optical constants of said material, comprising the steps of:

a1) providing a sample having a surface area, and an oscillating means having a separate surface area, said oscillating means being a part of an oscillator circuit such that it is caused to physically vibrate or support resonant or non-resonant acoustic waves when electrical potential is applied thereto;

a2) providing a chamber into which a fluid which contains a depositable material is caused to be present, as well as said sample and oscillating means.

Said method proceeds by simultaneously allowing deposit of said depositable material:

b1) onto the surface of said oscillating means before and/or while it is caused to vibrate or support resonant or non-resonant acoustic waves at a frequency; and

b2) onto the surface of said sample before and/or while a beam of electromagnetic radiation to interact with said surface area of said sample and then enter a data detector;

said material deposited on both surfaces being substantially similar;

c) in functional conjunction with step b) determining a relationship between a change in frequency of said oscillating means vs. effective thickness of material deposited thereupon, and providing a mathematical model of the sample and deopsited material system which includes effective thickness and optical constants of the deposited material;

d) analyzing change in frequency of said oscillating means to determine effective thickness of said deposited material, and performing regression of the data detector provided data onto said mathematical model to determine optical constants of said deposited material in view of said determined effective thickness.

Said method preferable provides that the beam of electromagnetic radiation which is caused to interact with said surface area of said oscillating means upon which material is deposited, and then enter a data detector be provided by an ellipsometer or polarimeter system which comprises, in a polarization state generator, a source of electromagnetic radiation and polarizing means, and in which said data detector is part of a polarization state detector which comprises analyzer means.

Said method can involve use of a quartz crystal as the oscillating means.

Said method can provide that the thickness is characterized by at least one selection from the group consisting of:

thickness per se;
surface coverage;
roughness; and
porosity.

Another modified method of determining density of material deposited onto a surface of an oscillating means comprising the steps of:

a) from a fluid containing a depositable material of known refractive index, causing a deposition thereof onto a surface of an oscillating means of known surface area, and detecting a change in the frequency of oscillation;

b) by application of an ellipsometer or polarimeter determining the product of the refractive index and thickness of said deposited material;

c) dividing the product of the refractive index and thickness of said deposited material determined in step b, by the known refractive index of said material to determine an effective thickness;

d) utilizing the known surface area of the oscillating means onto which said material is deposited, and the thickness of said material determined in step c, and the change in frequency of the oscillating means detected in step a which is proportional to the mass of the deposited material, determining the mass per unit volume.

The “effective thickness” can be viewed as an actual thickness per se., modified where necessary by such as surface coverage, roughness and material porosity.

The source of the beam of electromagnetic radiation which caused to interact with material deposited on said surface, can be an ellipsometer or polarimeter system which comprises, in a polarization state generator, a source of electromagnetic radiation and polarizing means, and in which said data detector is part of a polarization state detector which further comprises analyzer means.

Data accumulation can involve monitoring the change of frequency of the oscillating means as material is caused to deposit on a surface thereof, in functional combination with application of an ellipsometer or polarimeter system which comprises a source of electromagnetic radiation, polarizing means, analyzer means and a data detector to produce a polarized beam of electromagnetic radiation, cause it to interact with the material which has accumulated on the surface of the oscillating means, then pass through the analyzer and enter the data detector. It is noted that the oscillation frequency change data can be accumulated in real time during the accumulation of the said material on said surface of said oscillating means, or it can be taken before and after an accumulation, or at various stages during an accumulation. The polarimeter or ellipsometer data can also be taken in real time during material accumulation, or thereafter, or at various stages during an accumulation.

It is specifically noted that said accumulated material can be deposited, as by precipitation from a fluid, which can be characterized as a growth procedure in the case where biological material is present.

It is also disclosed that where the refractive index of a material is known or can be determined independently, then ellipsometry can be applied to determine the product of said refractive index and thickness, and by division the thickness of the material can be obtained. A change in frequency of an oscillating means onto which some of said material is deposited, in combination with its surface area, can then be utilized to determine the material density.

The disclosed invention will be better understood by reference to the Detailed Description of this Specification in combination with the Drawings.

SUMMARY OF THE INVENTION

It is therefore an objective and/or purpose of the disclosed invention to teach a system comprising a Quartz Microbalance and an ellipsometer system.

It is another objective and/or purpose of the disclosed invention to teach a method for uncorrelated determination of thickness and optical constants of materials.

It is yet another objective and/or purpose of the disclosed invention to teach a method for determining density of a material where its optical constants are known or can be otherwise determined, where ellipsometry is applied to determine thickness of a material on an oscillating means surface of known geometry.

Other objectives and/or purposes of the disclosed invention will be apparent upon a reading of the Specification and Claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1**, there is demonstrated an Ellipsometry system.

FIG. **2** demonstrates a system for depositing materials present in fluids onto Samples (SS) which are in a Chamber (CH), including Ports (P**1**) (P**2**) for use in providing fluid thereinto.

FIG. **3** shows that the Sample (SS) which is subjected to ellipsometric investigation, can have a Monitor (MON) electrically connected thereto which includes excitation and resonant frequency detecting capability.

FIG. **4** demonstrates that the small mass can be added to a witness sample (WS) which is separately monitored for change in resonant frequency, thereby not requiring the Sample (SS) which is subjected to ellipsometric investigation to be changed by attachment of electrodes thereto.

DETAILED DESCRIPTION

Turning now to FIG. **1**, there is demonstrated an Ellipsometry system. Note that a Source of Electromagentic Raditiaon (LS) provides a beam (LB) which has a polarization state set by Polarizer (P) and Optional Compensator (C**1**) prior to interaction with a Sample (SS). Shown after the Sample (SS) are both Reflection and Transmission scenarios, each of comprise an Analyzer (A) and Optional

Compensator (C2) (C3). Note that indications of Polarization State Generator (PSG) and Polarization State Detector (PSD) are shown.

FIG. 2 demonstrates a system for depositing materials onto Samples (SS) form a fluid entered via Port (P1) or P2). Shown are a Chamber (C) to which are affixed Polarization State Generator (PSG) and Polarization State Detector (PSD), as well Ports (P1) and (P2) for entry and exit of material containing fluids for Deposit onto the Sample (SS), or at least release into the vicinity thereof. It is noted that materials to be deopsited can be dielectrics, metals, insulators etc., or can comprise organic materials and the Sample (SS) can have a surface which has an affinity for deposited materials entered in a flow of fluid. Typical application of ellipsometry in a FIG. 2 configuration provides data that identifies a product of thickness and refractive index of, for instance, a thin film deposited on the upper surface of the shown Sample (SS).

FIG. 3 shows that the Sample (SS) which is subjected to ellipsometric investigation, can have a Monitor (MON) electrically connected thereto which includes excitation and resonant frequency detecting capability. As disclosed in the Background Section, a small mass (ΔM) added to the Sample (SS) induces a decrease in the resonant frequency (Δf) which is proportional to the (Δm). FIG. 4 demonstrates that the small mass can be added to a witness sample (WS) which is separately monitored for change in resonant frequency, thereby not requiring the Sample (SS) which is subjected to ellipsometric investigation to be changed by attachment of electrodes thereto. Similar separate system configurations are often utilized in Vacuum Deposition of materials onto Samples (SS), but not in conjunction with application of ellipsometry to enable de-correlation of deposited layer effective thickness and optical constants.

In general it is to be understood that the Chamber (CH) can be a controlled ambient chamber in which fluid is caused to be present, and can provide any functional material which deposits onto the surface of a Sample (SS), and optionally onto another surface which is part of an oscillating circuit. In addition, as shown in FIG. 1, material can be caused to be present on a surface of a Sample (SS) outside of a chamber.

It is noted that the change in frequency of an oscillating means, as a function of deposited material, is directly proportional to the mass of the deposited material. Based on surface geometry, this correlates to density and thickness of the material. Further, elipsometric models can include parameters which correspond to surface coverage, roughness and material porosity. Depending on what is known and what is desired to be evaluated, the various methods of this invention are applied.

Finally, the terminology "fluid" typically means liquid which remains liquid throughout to procedure, although a gas which contains a depositable material is also to be considered within the definition unless excluded by Claim language.

Having hereby disclosed the subject matter of the present invention, it should be obvious that many modifications, substitutions, and variations of the present invention are possible in view of the teachings. It is therefore to be understood that the invention may be practiced other than as specifically described, and should be limited in its breadth and scope only by the claims.

We claim:

1. A method of determining an effective thickness of a material deposited on a surface to form a combination of deposited material which is transformed by the deposition process to result in a concrete tangible combination with said surface, in uncorrelated combination with determination of optical constants of said material, comprising the steps of:

a1) providing an oscillating means having a surface area, said oscillating means being a part of an oscillator circuit such that it is caused to physically vibrate or support resonant or non-resonant acoustic waves when electrical potential is applied thereto;

a2) providing a chamber into which a fluid which contains a depositable material is caused to be present as well as said oscillating means;

b) simultaneously or sequentially:

b1) allowing said depositable material to deposit onto the surface of said oscillating means before and/or while it is caused to vibrate and/or support resonant or non-resonant acoustic waves at a frequency; and

b2) causing a beam of electromagnetic radiation to interact with said surface area of said oscillating means and then enter a data detector;

such that said oscillating means is transformed into a combination of said oscillating means per se. and a deposited layer of material on said surface thereof, said deposited material being present in a transformed concrete and tangible form caused by said deposition process, as opposed to being in a dispersed in fluid form, said deposited material present in said transformed concrete and tangible form being appropriate for investigation with electromagnetic radiation in a manner not possible where said material is dispersed in fluid;

c) in functional conjunction with step b) determining a relationship between a change in frequency of said oscillating means vs. effective thickness material deposited thereupon, and providing a mathematical model of the oscillating means and deposited material system which includes said effective thickness, and optical constants of the deposited material;

d) analyzing change in frequency of said oscillating means to determine effective thickness of said deposited material, and performing regression of the data detector provided data onto said mathematical model to determine optical constants of said deposited material in view of said determined effective thickness.

2. A method of determining uncorrelated thickness and optical constants of a deposited material as in claim 1 in which the beam of electromagnetic radiation caused to interact with said surface area of said oscillating means, upon which material is deposited, and then enter a data detector is provided by an ellipsometer or polarimeter system which comprises, in a polarization state generator, a source of electromagnetic radiation and polarizing means and in which said data detector is part of a polarization state detector which further comprises analyzer means.

3. A method of determining uncorrelated thickness and optical constants of a deposited material as in claim 1 in which the oscillating means is a quartz crystal.

4. A method of determining uncorrelated thickness and optical constants of a deposited material as in claim 1 in which the thickness is characterized by at least one selection from the group consisting of:

thickness per se;

surface coverage;

roughness; and

porosity.

5. A method of determining uncorrelated thickness and optical constants of a material deposited on a surface to form a combination of deposited material which is transformed by

the deposition process to result in a concrete tangible combination with said surface, comprising determining an effective thickness of a material in uncorrelated combination with optical constants of said material, comprising the steps of:

a1) providing a sample having a surface area, and an oscillating means having a separate surface area, said oscillating means being a part of an oscillator circuit such that it is caused to physically vibrate or support resonant or non-resonant acoustic waves when electrical potential is applied thereto;

a2) providing a chamber into which a fluid which contains a depositable material is caused to be present, as well as said sample and oscillating means;

b) simultaneously allowing said depositable material to:

b1) deposit onto the surface of said oscillating means before and/or while it is caused to vibrate or support resonant or non-resonant acoustic waves at a frequency; and

b2) deposit onto the surface of said sample before and/or while a beam of electromagnetic radiation to interact with said surface area of said sample and then enter a data detector;

said material deposited on both surfaces being substantially similar; such that said oscillating means and sample are each transformed into combinations of said oscillating means and sample per se. and a definite deposited layer of material on said surfaces thereof, said deposited material being caused to be present in a transformed concrete and tangible form by said deposition process as opposed to being in a dispersed in fluid form, said deposited material caused to be present on said sample in said transformed concrete and tangible form being appropriate for investigation with electromagnetic radiation in a manner not possible where said material is dispersed in fluid;

c) in functional conjunction with step b) determining a relationship between a change in frequency of said oscillating means vs. effective thickness of material deposited thereupon, and providing a mathematical model of the sample and deopsited material system which includes effective thickness and optical constants of the deposited material;

d) analyzing change in frequency of said oscillating means to determine effective thickness of said deposited material, and performing regression of the data detector provided data onto said mathematical model to determine optical constants of said deposited material in view of said determined effective thickness.

6. A method of determining uncorrelated thickness and optical constants of a deposited material as in claim **5** in which the beam of electromagnetic radiation caused to interact with said surface area of said oscillating means, upon which material is deposited, and then enter a data detector is provided by an ellipsometer or polarimeter system which comprises, in a polarization state generator, a source of electromagnetic radiation and polarizing means, and in which said data detector is part of a polarization state detector which comprises analyzer means.

7. A method of determining uncorrelated thickness and optical constants of a deposited material as in claim **5** in which the oscillating means is a quartz crystal.

8. A method of determining uncorrelated thickness and optical constants of a deposited material as in claim **5** in which the thickness is characterized by at least one selection from the group consisting of:

thickness per se;

surface coverage;

roughness; and

porosity.

9. A method of determining density of material deposited onto a surface of an oscillating means to form a combination of deposited material which is transformed by the deposition process to result in a concrete tangible combination with said surface, comprising the steps of:

a) from a fluid containing a depositable material of known refractive index, allowing a deposition thereof onto a surface of an oscillating means of known surface area, such that said oscillating means is transformed into a combination of said oscillating means per se. and a deposited layer of material on said surface thereof, said deposited material being present in a transformed concrete and tangible form caused by said deposition process, as opposed to being in a dispersed in fluid form, said deposited material present in said transformed concrete and tangible form being appropriate for investigation with electromagnetic radiation in a manner not possible where said material is dispersed in fluid;

and detecting a change in the frequency of oscillation;

b) by application of an ellipsometer or polarimeter determining the product of the refractive index and thickness of said deposited material;

c) dividing the product of the refractive index and thickness of said deposited material determined in step b, by the known refractive index of said material to determine an effective thickness;

d) utilizing the known surface area of the oscillating means onto which said material is deposited, and the thickness of said material determined in step c, and the change in frequency of the oscillating means detected in step a which is proportional to the mass of the deposited material, determining the mass per unit volume.

10. A system comprising a chamber having port means for entering and exiting fluid which contains depositable material, said chamber comprising therewithin an oscillating means having a surface area, said oscillating means being a part of an oscillator circuit such that it is caused to physically vibrate or support resonant or nonresonant acoustic waves when electrical potential is applied thereto; and said chamber having affixed thereto a polarization state generator and polarization state detector;

such that in use material is allowed to deposit onto the oscillating means surface area from fluid containing depositable material which is entered thereinto via said port means, thereby transforming said oscillating means into a combination of said oscillating means per se. and a deposited layer of material on said surface thereof, said deposited material being present in a transformed concrete and tangible form caused by said deposition process, as opposed to being in a dispersed in fluid form, said deposited material present in said transformed concrete and tangible form being appropriate for investigation with electromagnetic radiation in a manner not possible where said material is dispersed in fluid; and

said system sequentially or simultaneously enabling:

electrical potential to be applied to said oscillating means and change in the frequency of oscillation is monitored during said material deposition; and

a beam of electromagentic radiation provided by said polarization state generator to be caused to interact with said depositable material being deposited onto said oscillating means surface area or an alterative surface area, and then enter said polarization state detector.

11. A system as in claim **10** which further comprises a sample present in said chamber, said sample having a surface area upon which said material being deposited onto said oscillating means surface area also deposites, such that said sample is transformed into a combination of said sample per se. and a deposited layer of material on said surface thereof, said deposited material being caused to be present in a transformed concrete and tangible form bysaid deposition process, as opposed to being in a dispersed in fluid form, said deposited material caused to be present on said sample in said transformed concrete and tangible form being appropriate for investigation with electromagnetic radiation in a manner not possible where said material is dispersed in fluid, and in which said beam of electromagnetic radiation provided by said polarization state generator is caused to interact with at least one selection from the group consisting of;

said material deposited on said oscillating means surface area; and

said material deposited on said sample surface area.

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