QUALITY MONITOR AND MONITORING TECHNIQUE EMPLOYING OPTICALLY STIMULATED ELECTRON EMMISSION

ORIGIN OF THE INVENTION

The invention described herein was jointly made by an employee of the United States Government and NASA contract employees during the performance of work under NASA Contract Nos. NAS1-18347 and NAS1-19236, and is subject to the provisions of Public Law 96-517 (35 USC 202) in which the contractors have elected not to retain title.

BACKGROUND OF THE INVENTION

1. Technical Field

The present invention relates generally to the nondestructive evaluation of surface contamination levels and more particularly to improvements to an apparatus and method of monitoring optically stimulated electron emission.

2. Discussion of the Related Art

It is often desirable to monitor the quality and conditions of a surface for various manufacturing processes. For example, the indication, identification and quantification of contaminants such as grease or dirt are vital in painting or coating processes, forming laminates, inspection for cyclic loading, maintaining the cleanliness of memory disc drive heads, etc. One area of particular interest is the placement of coatings or oxides having critical thicknesses onto the surfaces of semiconductor wafers to fabricate microelectronic components.

Several techniques are available to quantitatively observe and to quantitatively measure the condition of a surface and include direct or magnified observation, profilometers, ellipsometry, low energy electron diffraction, Augur electron spectroscopy and scanning electron microscopy. These techniques often require bulky equipment and are difficult for a relatively unskilled technician to operate.

A surface contamination monitor is commercially available from Photo Acoustic Technology, Inc. of Newbury Park, Calif. This surface contamination monitor is described in U.S. Pat. No. 4,590,376 to Tennyson Smith. An ultraviolet light is directed onto the surface of interest, causing photoelectrons to be emitted. These emitted photoelectrons are detected and compared to previously established values for surface conditions to determine acceptability based on criteria such as oxide thickness, contamination or fatigue. This technique is often referred to as Optically Stimulated Electron Emission, or OSEE. The prior OSEE monitor is described in greater detail in the Detailed Description of the present application.

This surface contamination monitor, while offering improved surface monitoring, has several drawbacks. The OSEE indications for a given measurement are time dependent, generally decreasing from an initial high value. For a given sample preparation, there is a large variability of initial values which can be obtained both among samples prepared the same way and from a single sample measured at different times over a period of several days. On a given extended sample measured by scanning, indications of contamination may persist in specific regions, even through several cycles of recleaning. This continued indication of contamination and subsequent good surface performance identify the indications as false positive contamination indications. Finally, oxidation is promoted on some metallic surfaces from exposure to the OSEE probes over extended times. Further drawbacks are discussed in the Detailed Description of the present application.

Objects

It is accordingly an object of the present invention to increase the stability of optically stimulated electron emission measurements.

It is another object of the present invention to increase the reproducibility of optically stimulated electron emission measurements.

It is a further object of the present invention to increase the definition of optically stimulated electron emission measurements.

It is another object of the present invention to increase the sensitivity of optically stimulated electron emission measurements.

It is a further object of the present invention to decrease the ambiguity of optically stimulated electron emission measurements.

It is another object of the present invention to extend the range of substrates measured by optically stimulated electron emission measurements to include non-conductors.

It is a further object of the present invention to accomplish the foregoing objects in an economical, straightforward manner.

Additional objects and advantages of the present invention are apparent from the drawings and specification which follow.

Summary

The foregoing and additional objects are obtained by a quality monitor and quality monitoring technique employing optically stimulated electron emission according to the present invention. A light source directs ultraviolet light onto a test surface and a detector detects a current of photoelectrons generated by the light. The detector includes a collector which is positively biased with respect to the test surface. Quality is indicated based on the photoelectron current. The collector is then negatively biased to replace charges removed by the measurement of a nonconducting substrate to permit subsequent measurements. Also, the intensity of the ultraviolet light at a particular wavelength is monitored and the voltage of the light source varied to maintain the light a constant desired intensity. The light source is also cooled via a gas circulation system. If the test surface is an insulator, the surface is bombarded with ultraviolet light in the presence of an electron field to remove the majority of negative charges from the surface. The test surface is then exposed to an ion field until it possesses no net charge. The technique described above is then performed to assess quality.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic diagram of a prior art monitor for measuring optically stimulated electron emission;

FIGS. **2***a* and **2***b* are schematic diagrams of prior art light sources and resulting illuminated areas of the test surface;

FIG. **3** is a schematic diagram of an OSEE monitor improved according to the present invention;

FIG. **4** graphs the OSEE photocurrent responses with respect to various wavelengths of light;