PACKAGE ID - 000807MQUAD00 SIFTIR

KWIC TITLE - Oxygen Analysis in Silicon Using Fourier Transform Infrared Spectroscopy

AUTHORS - Stevenson, J.O.
Sandia National Labs., Albuquerque, NM (United States)

Medernach, J.W.
Sandia National Labs., Albuquerque, NM (United States)

LIMITATION CODE -COPY **AUDIENCE CODE -** LIM

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DESCRIPTION - The interstitial oxygen concentration in Czochralski silicon and the subsequent silicon oxide precipitation are important parameters for integrated circut fabrication. Uncontrolled silicon oxide precipitation during processing can create detrimental mechanical and electrical effects that contribute to poor performance. An inability to consistently and accurately measure the initial oxygen concentration in heavily doped silicon has led to contradictory results regarding the effects of dopant type and concentration on silicon/oxide precipitation. We have developed a software package for reliably determining and comparing oxygen in heavily doped silicon. The code implements three independent analysis methods in a single integrated package. Routine oxygen measurements are desirable over a wide range of silicon resistivities, but there has been confusion concerning which of the three numerical methods is most suitable for the low resistivity portion of the continuum. A major strength of the software is an ability to rapidly produce results for all three methods using only a single Fourier Transform Infrared Spectroscopy (FTIR) spectrum as input. This ability to perform three analyses on a single data set allows a detailed comparison of the three methods across the entire range of resistivities in question. Integrated circuit manufacturers could use the enabling technology to monitor oxygen content. Early detection of oxygen using this diagnostic could be beneficial in controlling silicon oxide precipitation during integrated circuit processing.

PACKAGE CONTENTS - Media Directory; Software Abstract; SAND93-0349; SAND91-2764; Media Includes Source Code, Executable Modules, Auxiliary Material, Sample Problem Input and Output Data, Programmer Documentation, Readme File - Describes Disk Contents and Proper Usage of SIFTIR;

SOURCE CODE INCLUDED? - Yes

MEDIA QUANTITY - 1 3.5 Diskette

METHOD OF SOLUTION - We have developed a three-step technique for determining Oi in heavily doped silicon: Selective Electrochemical

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METHOD OF SOLUTION -(CONT) thinning of a limited area of a wafer, FTIR transmittance measurements on the thinned areas, and oxygen analysis of the FTIR spectra using this software package. The oxygen concentration is determined from FTIR data. Routine oxygen measurements are desirable over a wide range of silicon resistivities, but the FTIR technique has certain limitations in that regard. The absorption band for the localized silicon oxide is readily detected by FTIR on lightly doped silicon of standard thicknes. The oxygen content of heavily doped silicon cannot be reliably measured on standard thickness wafers by FTIR transmittance due to the interference from free carrier absorption. The frequency dependence of the free carrier absorption causes significant baseline curvature and shrouds the weak oxygen band. As a result, calculations assuming a linear baseline tend to overestimate oxygen. Determination of oxygen in heavily doped silicon usually employ some form of bulk wafer thinning to reduce free carrier absorption effects and allow FTIR measurement. The package is able to analyze FTIR absorbance or transmittance data and calculate oxygen according to three seperate algorithms: standard test method, short baseline technique , and curved baseline technique. The algorithms are founded on equations discussed in the open literature of silicon.

COMPUTER - MAC QUADRA

OPERATING SYSTEMS - SiFTR was developed on a Macintosh Quadra 900 running the standard Macintosh Operating System (MacOS) System 7.0.1. Versions were also developed for DOS and VMS systems. No modifications were made to these operating systems.

PROGRAMMING LANGUAGES - FORTRAN (100%).

SOFTWARE LIMITATIONS - Input files need not be MPW document files (Word for the Mac input files work just fine, as will other text files). However, although package runs entirely with MacOS, the output files produced by are MPW document files and are designed to be opened in the MPW shell. While MPW document files are text files and may be opened by text editors other than the MPW editor, the formatting will be irregular and highly uncertain. Therefore, MPW must be purchased and installed for the package to execute properly. Please do not use without installing MPW.

SOURCE CODE AVAILABLE (Y/N) - Y

UNIQUE FEATURES - Code implements three independent oxygen analysis methods in single package. Routine oxygen measurements are desirable over wide range of silicon resistivities. A number of equations in literature were shown to be very unstable over particular data regimes. A correction for multiple internal reflections was most glaring numerical instability. Precision was being lost in many instances. These equations were reformulated to

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UNIQUE FEATURES -(CONT) minimize numerical instabilities and to preserve accuracy that might be lost. A major strength of the software is abiity to rapidly produce results for all methods using only single spectrum as inut. Integrated circut manufacturers could use the enabling technology to monitor oxygen content. Early detection of oxygen using this could be beneficial in controlling silicon-oxide precipitation during integrated circut processing. Early detection of oxygen impurities could minimize costly device failure. Determination of oxygen in heavily doped silicon usually employs some form of bulk wafer thinning to reduce free carrier absortpion effects and allow FTIR measurement. Thinning is achieved by mechanical lapping or chemically etching an entire wafer to the desired thickness. Double-side polishing is performed in some cases. Bulk wafer thinning has the serious disadvantage of critically altering the entire thickness dimension, thereby precluding additional wafer processing in many instances. Bulk wafer thinning also compromises the structutal integrity of the silicon substrate. Certain process lines are incapable of handling such altered wafers. Our three step technique for determining oxygen in heavily doped silicon: SE thinning of limited area of wafer, FTIR transmittance measurements on thinned areas, and oxygen analysis of FTIR spectra minimizes these deleterious effects.

RELATED SOFTWARE - Is currently operating as a research code. SiFTR reads the spectral data from the Nicloet 60SX FTIR spectrometer in a variety of different formats, including X-Y pairs and JCAMP. SiFTR requires these external data files for execution. The user is propmted for the names of these FTIR input files, without which, there are no data to be analyzed for oxygen content.

OTHER PROG/OPER SYS INFO - Is a Macintosh application designed to run alongside the powerful Macintosh Programmer's Workshop (MPW). MPW is an application that runs on top of the Macintosh Operating System (MasOS). Input files need not be MPW document files (Word for the Mac input files work just fine, as will other text files).

HARDWARE REQS - No special hardware requirements (a math co-processor should be resident).

TIME REQUIREMENTS - No special time requirements. The spectral data files generated by the Nicloet 60SX FTIR spectrometer are not very large and the computations are relatively fast. Responds to input within a few seconds to under a minute, depending on computing power of the system.

REFERENCES - Stevenson, J.O., Medernach, J.W., Numerical Methods for Determining Interstital Oxygen in Silicon, (January 1, 1995); Medernach, J.W., Stein, H.J., Stevenson, J.O., Selective Electrochemical Wafer Thinning for Silicon Characterization, (March 1, 1993)

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SUBJECT CLASS CODE - UQO

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S CODES
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SILICON OXIDES

EDB SUBJECT CATEGORIES -
990200 400102 665000

SPONSOR - DOE/DP

PACKAGE TYPE - SCREENED