FTIR measurement of nitrogen in silicon using shuttle
type sample stage

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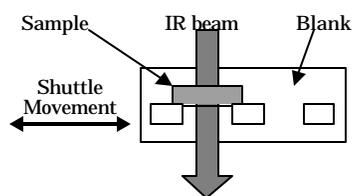7-6 Higashi-Ueno 2-chome, Taito-ku, Tokyo, Japan

Fig.1 Shuttle type sample stage. It has sample holders, one for sample and the other for blank. It moves back and forth to measure them alternatively.

Introduction

     Nitrogen is doped to control COP and oxygen precipitation. Nitrogen in silicon has some strong infrared absorptions but doping level of order of ppb makes use of FTIR very difficult. 10mm thick double side polished sample is currently used for the nitrogen measurement by FTIR. For a measurement of samples less than 2mm thick, high sensitivity and stable baseline is crucial to detect such weak nitrogen peaks sitting on the silicon lattice absorption band.

Shuttle stage

     Long measurement time is effective to reduce noise level. To accumulate sample and blank spectra with minimum instrument instability, a shuttle type sample stage, as shown in Fig.1, was used. Sample and blank were measured alternatively by moving the stage back and forth in short period. It is equivalent to measure both of the samples and blank simultaneously for required long measurement time. Any time-dependent instability will be cancelled out. As shown in Fig.2, stability of baseline is improved very much.

Noise level

     2mm double side polished nitrogen doped CZ sample was measured twice, as reference and as sample, by different number of scans, up to 8000 scans. 100% line was calculated from 1st and 2nd spectra and was quite flat as shown in Fig.3. Increasing a number of scans decreases noise level as

     Noise level $\propto$ (number of scans)$^{-0.5}$

This means that noise in Fig.3 is random noise. Noise level of 3.12×10^{-6} by 4000 scans is equivalent to detect 1.97×10^{13} cm^{-3} nitrogen concentration with S/N=3. Conversion coefficient used to estimate this detection limit was 1.83×10^{17}cm^{-2} (1). This means FTIR has enough sensitivity for the practical nitrogen measurement.

Nitrogen peak

     Detection of extremely small peaks is influenced by baseline shape. As shown in Fig.4, difference spectrum shows irregularities some of which are related to silicon lattice band. Local baseline (2) makes 766 cm^{-1} nitrogen peaks more well defined. Smaller number of scans for practical measurement makes S/N ratio worse. Etched sample surface introduces baseline undulation. Data processing such as deconvolution or apodizatoin will help to enhance absorption peak in both cases.

Acknowledgement

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References

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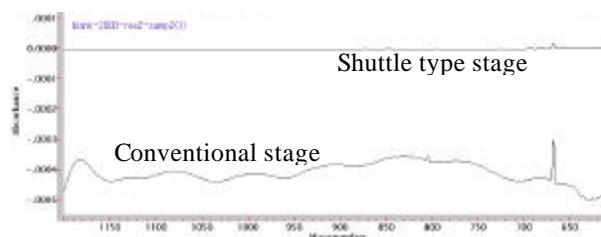

Fig.2 Baseline stability. 100% lines of two successive 2000 scans show that baseline using a shuttle type sample stage is straighter than one using a conventional stage. Two plots are shifted vertically for convenience.
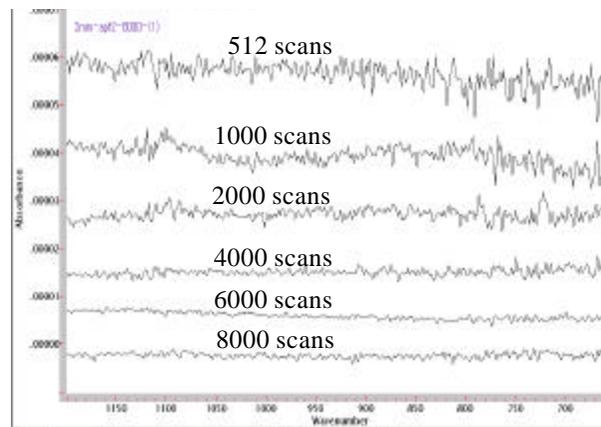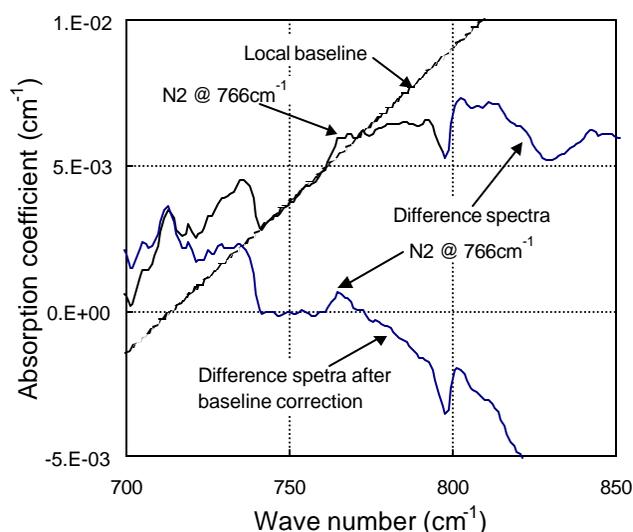

Fig.3 Noise level. 100% lines of two successive scan of 2mm sample show that decrease of noise level by increasing the number of scans. Each plot is shifted vertically for convenience.

Fig.4 Nitrogen peak at 766 cm^{-1}. Difference spectrum shows some irregularities so that local baseline is used make nitrogen peak clearer.