Quantitative Analysis and Comparison of Endpoint Detection Based on Multiple Wavelength Analysis

Herbert H. Sawin, Brian E. Goodlin, Duane S. Boning
MIT
77 Mass. Ave., 66-219
Cambridge, MA 02139

Endpoint detection has been utilized for many years to improve control over plasma etching processes. Unfortunately, for low open area etches (<1%) including contact and via etches, traditional endpoint detection methods have been unsuccessful because of the low signal to noise ratio of the optical emission techniques.

Over the past couple of years, we have worked on methods for improving the sensitivity of endpoint detection through the use of multi-wavelength optical emission spectroscopy detectors. A quantitative method was developed for comparison of endpoint detection sensitivity based on signal-to-noise ratio at endpoint. Traditional approaches to multivariate quality control, such as Hotelling's T^2 [1] were applied to the data as well as chemometrics methods such as principal component analysis (PCA) [2]. A quantitative comparison of these and other endpoint analysis techniques will be discussed. For example, Hotelling's T^2 analysis showed improvements in endpoint detection sensitivity of 2-4 over traditional single wavelength methods.

A new method for endpoint detection was developed to optimize endpoint detection sensitivity called the *MSN* or *multivariate statistic weighted by signal to noise ratio* [3]. This technique is theoretically the optimum technique for multivariate analysis based on linear combinations. Side-by-side comparisons will be presented for this and other multivariate techniques currently being used for endpoint detection.

The improvement in endpoint detection through the use of more than one wavelength ultimately depends on the nature of the noise in the process. If shot noise is the limitation, reasonable improvements are easily obtainable since the noise is not highly correlated. When other disturbances become prevalent that cause correlated noise, such as drift or interferometry noise [4], the multivariate methods often have difficulty rejecting these disturbances leading to minimal improvements over single wavelength methods. In such cases, it is better to filter out the disturbance first by other means (such as time series modeling or bandpass filters) before applying the multivariate algorithm.

References

1. D. White, B. Goodlin, A. Gower, D. Boning, H. Chen, H. Sawin, T. Dalton, *IEEE TSM*, 13 (2), 2000.
2. B. Goodlin, Ph.D. Thesis, MIT, 2002 (not yet published).
3. B. Goodlin, H. Sawin, D. Boning, *AEC/APC Symposium XIII*, Banff, Canada, 2001.
4. B. Goodlin, H. Sawin, D. Boning, M. Yang, *Proc. Of ECS: Plasma Processing XIII*, Toronto, May 2000.