Development of the Virtual Metrology Using a PlasmaInformation Variable (PI-VM) for Monitoring SiO_2 Etch Depth

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Advanced process control (APC) has been attractingattention as a technology to enhance process yield and it requires accurate andreliable virtual metrology (VM). Accuracy of VM is determined by howsensitively the input variables reflect the drift and changes of the processenvironment. Many previous approaches to improve the performance of VM have beenfocused on development of the statistical methods to select the valuable input variablesfrom the equipment data and additional sensor data such as optical emission spectroscopy(OES) and plasma impedance monitors (PIM). In this study, the noble variables,named plasma information (PI) variables are introduced, which are obtained byphenomenological analysis and they are added into the VM development. It notes that PI variablesrepresents the state of etch plasma so it can be used to monitor the variationof process results in plasma-assisted semiconductor fabrication process. Effectof PI variables on improving VM accuracy has been investigated through followingconventional (or standard) VM development procedures; 1. preprocessof input dataset, 2. data exploration, 3. variable selection, 4. training of a model,and 5. Validation of the model. We added PI variables in the steps (i) in-between2 and 3 steps (called PI-VM_{STA}) and (ii) in-between 3 and 4 steps(called VM_{STA}+PI). Each VM model is developed and evaluated byusing 50 sets of SiO_2 etching depth data, having 20:1 aspect ratioand less than 5 % of variation. PI_{EEDF}, representing variation ofelectron energy distribution function (EEDF) is obtained from analysis of OES,which is based on the argon excitation kinetics. Pearson’s correlation filter,principal component analysis (PCA), and stepwise variable selection are usedfor the variable selection methods. Results show that VM models using PI_{EEDF}have better performance than any other conventional VM models because PI_{EEDF}has much higher correlation with output variable than the other equipmentand sensor variables. Especially, PI-VM_{STA} using stepwise variableselection method shows the highest accuracy where PI_{EEDF} provides abasis to select other OES variables. This study shows that a phenomenological-based,statistically tuned VM can be developed by using PI variables as input. It hasadvantages for management of dataset and selection of control variables in APCapplication.