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Modeling and controlling of defect generation in electronic devices during plasma etching processes—an optimization methodology of plasma-induced damage

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Tremendous efforts have been devoted to the development of plasma etching processes in order to meet the increasing demand for higher performance of electronic devices. Plasma etching plays an important role in achieving fine patterns, where a plasma—device surface reaction should be atomically controlled. This study comprehensively addresses one of the negative aspects of plasma etching, i.e., ion bombardment damage—plasma-induced physical damage (PPD) [1][2]. Firstly, the typical defect structures and their impacts on the performance of etching process and device designs were briefly reviewed on the basis of experimental observations in combination with molecular dynamics and quantum mechanical calculations [3]. Not only the special profiles but also the energy states of created defects were principal parameters for controlling the PPD in plasma etching processes. An improved PPD range model was proposed, where the ion dose (D_{ion}) dependence of the damaged layer formation was implemented in addition to the energy dependence. Then, the model prediction results were compared with the experimental data recently reported [4]. From the obtained evidences, it was concluded that PPD in plasma etching processes should be designed by taking into account the D_{ion} dependence. Finally, a methodology—how to control PPD by optimizing plasma etch parameters—was discussed on the basis of the present model prediction results as future perspectives. Since PPD is the intrinsic nature of plasma etching, the process design is defined as an optimization problem under the constraints imposed by plasma and device performance criteria. [1] G. S. Oehrlein, Mater. Sci. Eng. **B** **4**, 441 (1989). [2] K. Eriguchi, J. Phys. D: Appl. Phys. **50**, 333001 (2017). [3] Y. Yoshikawa and K. Eriguchi, Jpn. J. Appl. Phys. **57**, 06JD04 (2018). [4] T. Hamano and K. Eriguchi, Jpn. J. Appl. Phys. **57**, 06JD02 (2018).