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Fundamental research into a microwave-driven remote plasma source

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Remote plasma sources (RPS) operated by microwave power are widely used for different industrial etching applications, e.g. decapsulation of semiconductor chips for failure analysis, cleaning of plasma deposition chambers in semiconductor industry and production of micro components. The special feature of an RPS is limitation of the plasma to the plasma chamber inside the RPS. Being connected to the process chamber, only radicals produced in the plasma will migrate from the plasma chamber of the RPS into the process chamber and act on the surface of the substrate to be treated, thus avoiding any impact of bombardment by charged particles. Therefore, only chemical etching by radicals will occur in the process chamber. Fundamental understanding of the processes inside the plasma chamber of the RPS is necessary for improving process parameters, i.e. the etching rate in particular. Therefore, microwave coupling into and microwave distribution inside the plasma chamber were modeled by two different finite element method (FEM)-based simulation programs, namely COMSOL Multiphysics and CST MICROWAVE STUDIO. The simulation results obtained showed to be in very good agreement. Based on these results, a new RPS was developed and analyzed concerning different experimental parameters. Experimental characterization of the ignition process is fundamental for understanding the basics of the RPS and the most efficient way for microwave injection. Therefore measurements of the ignition time representing the time delay between microwave injection into the plasma chamber and final plasma ignition as well as of the time-dependent average light intensity and optical emission spectra providing information on the energetic state of the radicals and ions was performed. In addition, the kinetic behavior of the plasma during the ignition process was observed by a high speed camera system. The correlation of the respective simulated and experimental values and results will be presented in this paper. Finally, the improvements achieved with the newly developed RPS were evaluated by etching tests on standardized samples.

Keywords
Remote plasma source
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Microwave Plasma