Designand Fabrication of Silicon Photonics Grating Couplers for Spatially ResolvedPlasma Uniformity Monitoring Sensor

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As semiconductortechnology node moves towards down to 10 nm scale node, the importance ofplasma processes cannot be overemphasizes. Not only meeting the requiredprocess result, but also monitoring of wafer-in-process (WIP) status employing additionalin-situ sensors. Various efforts of in-situ plasma process monitoring usingoptical emission spectroscopy and current-voltage prove are being investigated,but the plasma uniformity monitoring has not been investigated yet due to thelimitation of the process perturbation. WIP in the plasma chamber experiences ionbombardment associated with high RF power and electrical forces by the electrostaticchuck. Thus, direct monitoring of plasma uniformity using electrical method islimited to its application. In this paper, we propose a silicon photonics basedgrating couplers to vertically couple the plasma emission normal to the wafersurface inside the chamber, and the collected plasma emission is transmittedvia optical waveguide. Geometric structure of the grating coupler determinesthe plasma emission lines to be collected by grating coupler by enhancing theoptical coupling efficiency of the specific wavelength in visible spectra. Weconsidered silicon oxide etching process in this study and the couplingefficiency of the oxygen emission intensity at 777 nm is found to be as high as70%through a various finite-difference time-domain (FDTD) simulation. Theoptimized grating coupler design with waveguide is then fabricated to verifythe technical feasibility to be applied for the on-wafer type plasma uniformitysensor. Plasma emission is in visible spectral range, thus we developed siliconnitride core with silicon oxide cladding, which is different from conventionalsilicon waveguide with silicon on insulator (SOI) wafer. Both LPCVD and PECVD areused to fabricate the silicon photonics core and waveguide materialsrespectively, and KrF lithography is followed to have about 200 nm featuredgrating patterning. We successfully demonstrated the design and fabrication ofthe suggested silicon photonics devices on 200 mm wafer.