DETERMINING THE CONCENTRATIONS AND TEMPERATURES OF PRODUCTS IN A $CF_4/CHF_3/N_2$ PLASMA VIA SUBMILLIMETER ABSORPTION SPECTROSCOPY

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Plasmas used for the manufacturing of semiconductor devices are similar in pressure and temperature to those used in the laboratory for the study of astrophysical species in the submillimeter (SMM) spectral region. The methods and technology developed in the SMM for these laboratory studies are directly applicable for diagnostic measurements in the semiconductor manufacturing industry. Many of the molecular neutrals, radicals, and ions present in processing plasmas have been studied and their spectra have been cataloged or are in the literature. In this work, a continuous wave, intensity calibrated SMM absorption spectrometer was developed as a remote sensor of gas and plasma species. A major advantage of intensity calibrated rotational absorption spectroscopy is its ability to determine absolute concentrations and temperatures of plasma species from first principles without altering the plasma environment. An important part of this work was the design of the optical components which couple $500 - 750$ GHz radiation through a commercial inductively coupled plasma chamber. The measurement of transmission spectra was simultaneously fit for background and absorption signal. The measured absorption was used to calculate absolute densities and temperatures of polar species. Measurements for CHF_3, CF_2, FCN, HCN, and CN made in a $CF_4/CHF_3/N_2$ plasma will be presented. Temperature equilibrium among species will be shown and the common temperature is leveraged to obtain accurate density measurements for simultaneously observed species. The densities and temperatures of plasma species are studied as a function of plasma parameters, including flow rate, pressure, and discharge power.