Characterization of atmospheric electrodeless microwave plasma in nitrogen

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Thermal plasmas have been used for the decomposition of hazardous gases from semiconductor manufacturing processes. The gases are typically diluted by inert nitrogen before the treatment, and oxygen or air is injected into plasmas to prevent any recombination reactions. Arc plasmas have been used and studied most but suffer from electrode corrosion and small plasma volume. In this study, we investigate atmospheric microwave plasmas produced with the absence of electrodes while having larger plasma volume in pure nitrogen. Optical emission spectroscopy is conducted to measure the translational, rotational, and vibrational temperatures of the plasma. Then 3-temperature plasma kinetic simulations that consider the trans-rotational, vibrational, and electron temperatures separately are developed and conducted to have reaction pathways that sustain the plasma. The translational, rotational, and vibrational temperatures of the plasma are found to reach about 6000 K independent of flow rates and be all same so that the microwave plasma studied is thermal. The energy balance and measured temperatures show that still only portion of the flow directly goes through the plasma region and the portion that bypasses the region become larger as the flow rate increases. In the plasma region, the molecular nitrogen is found to be dissociated into atoms in a significant extent because of high gas temperature, and the plasma is sustained via associative ionizations rather than the electron-impact ionizations.

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