Analysis of Computational Work in Comparison with Experimental Results for an Atmospheric Pressure Microwave Plasma

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Introduction

Goal: To study the efficiency of an atmospheric pressure microwave plasma source at CO_2 conversion to CO using an experimental system as well as a computational program, Global_kin

Approach: Use mass spectrometry (MS) and optical emission spectroscopy (OES) to experimentally determine efficiencies and plasma properties. Utilize Global_kin, a zero-dimensional global kinetic model to computationally determine efficiencies and plasma properties. The model can take into account over 100 different reactions between electrons, neutrals, and ions to determine species densities in the simulated plasma for a given power level, pressure, and initial species mole fractions.

Results: Experimental and computational results match well for high values of specific energy input while at low values the computational results give lower efficiencies.

Experimental Setup

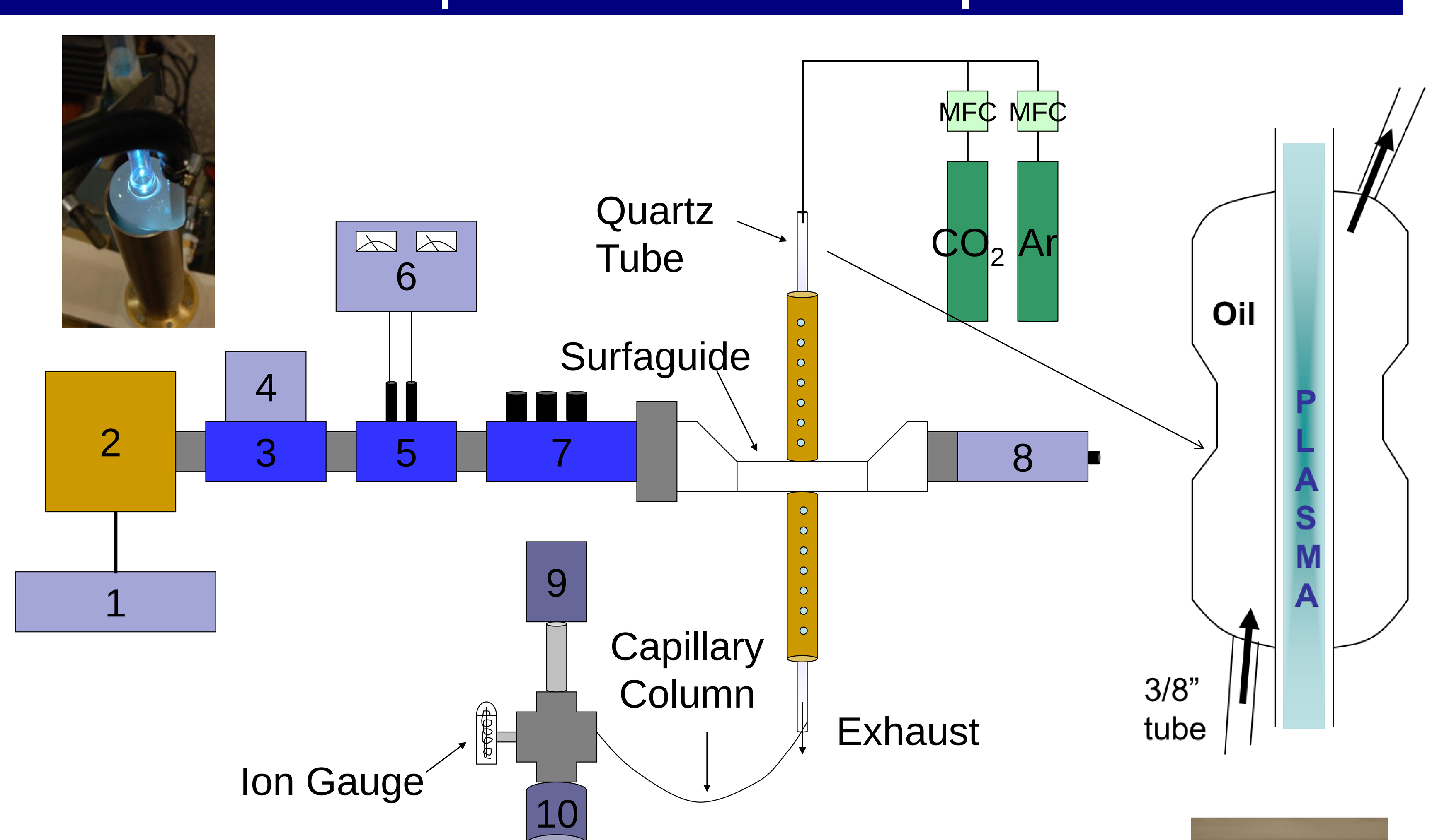
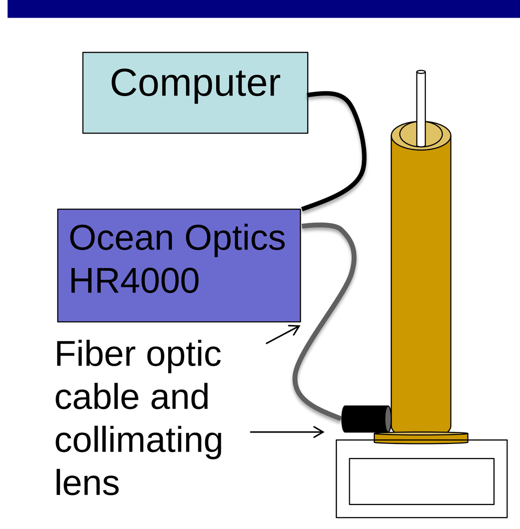
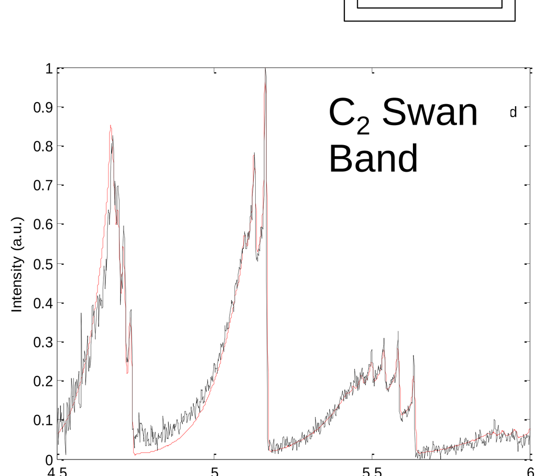


Fig. 1: Microwave plasma setup. 1) 2-kW power supply, 2) Magnetron head, 3) Three-port circulator, 4) Dummy load, 5) Directional coupler, 6) Power meters, 7) Three-stub tuner, 8) Sliding short circuit, 9) RGA, 10) Turbo pump.

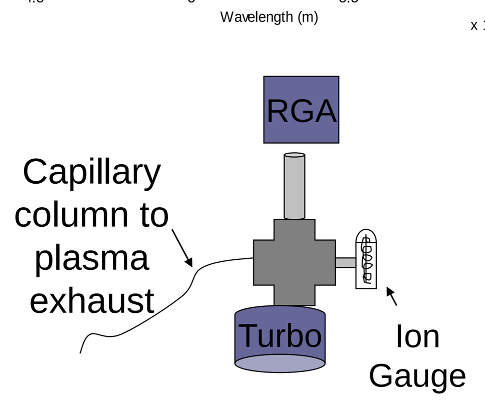
Diagnostics



- Ocean Optics HR4000 was used to take OES measurements
- The collimating lens, attached to fiber optic cable, was positioned at the most central point of the plasma, which corresponds to the brightest section



- The C_2 Swan Band was simulated in SpecAir and matched to the experimental band spectrum to compute vibrational, translational, rotational, and electronic temperatures



- Stanford Research Systems RGA100 was used to take MS data
- A capillary column of 0.102mm ID was used to sample gas at atmospheric pressure while maintaining RGA pressure below 1e-4 Torr

Questions? Contact Laura Spencer at laspen@umich.edu

Experimental vs. Computational Results

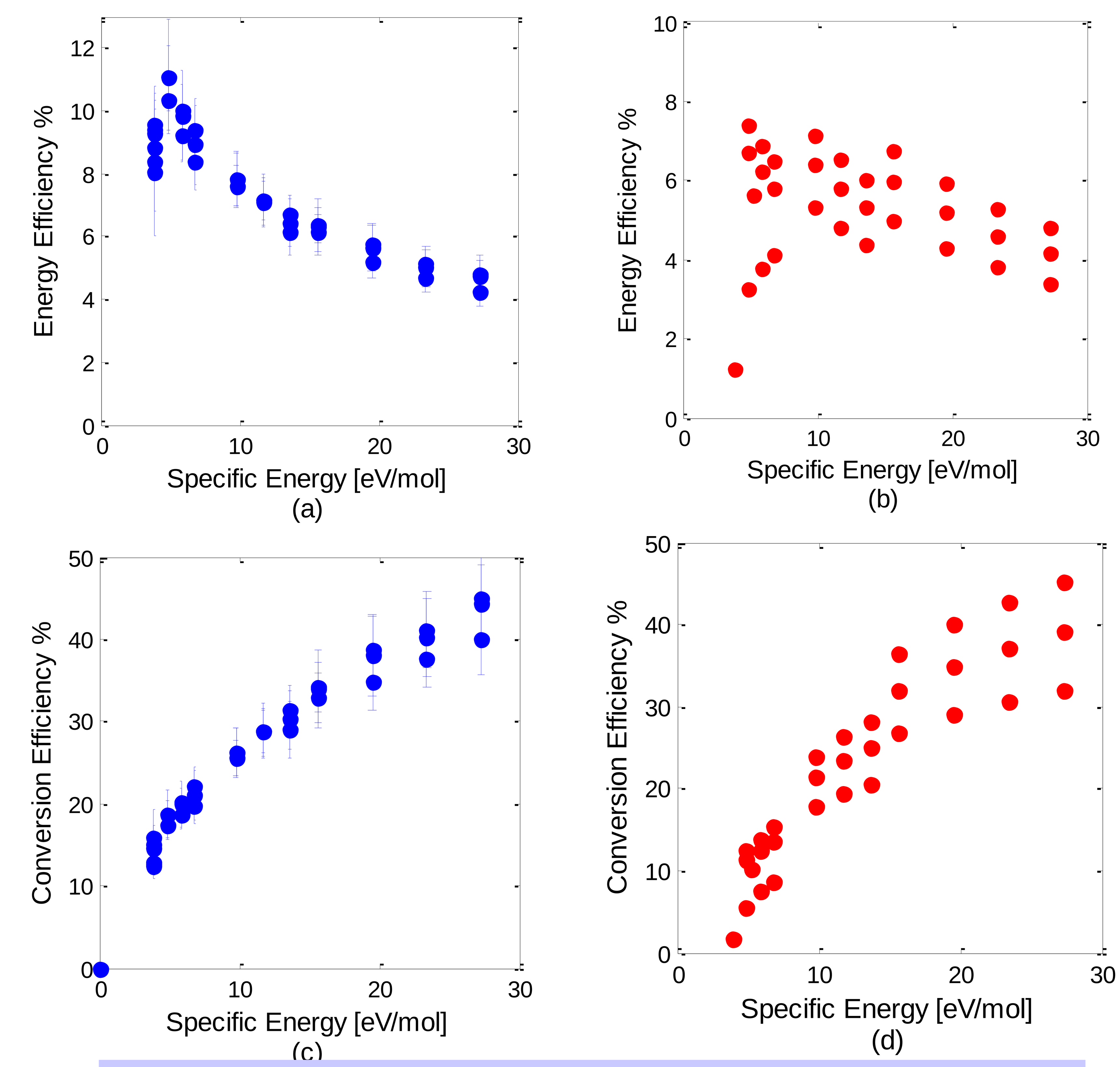


Fig. 2: Experimental results for energy efficiency (a) and conversion efficiency (c), in comparison with computational results for energy efficiency (b) and conversion efficiency (d).

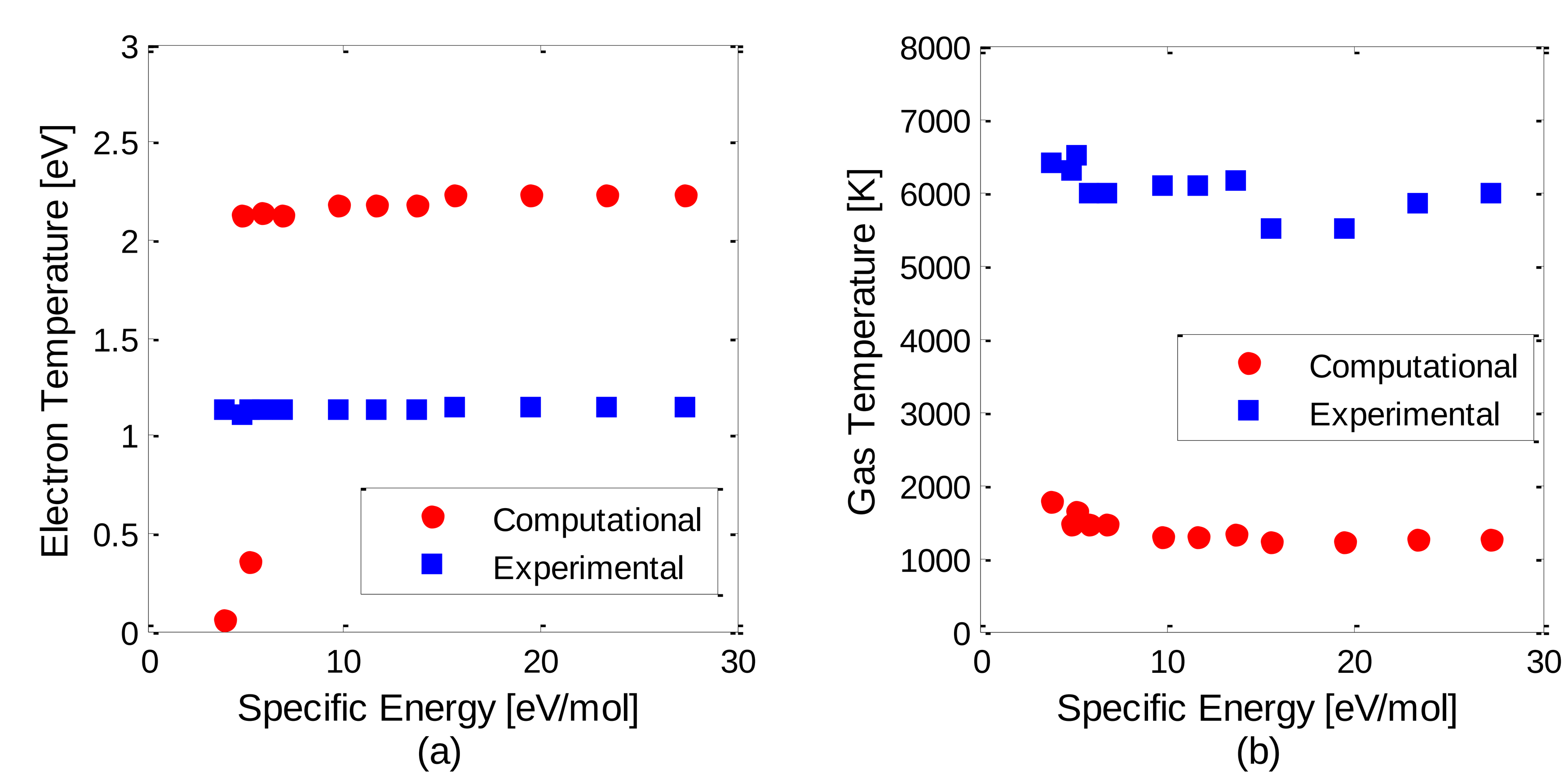


Fig. 3: Experimental and computational results for electron temperature (a) and gas temperature (b).

New Discharge Tube Design

- A new discharge tube designed in AutoDesk and modeled in Fluent will be developed to eliminate the need for a tube-cooling system requiring the use if a chiller
- This tube design will use tangential gas injection to create a vortex flow along the circumference of the tube to act as a gas insulation layer between the plasma and the quartz