

Research Interests:

Outside of life (plants and animals) I find process plasmas to be the most complex and intriguing systems observed on earth. This complexity draws me to the subject – I want to develop a global understanding of the processes that make process plasmas so useful and variable.

I view all process plasmas as a continuum. Thus plasmas used for etch are in many respects the same as plasmas used for deposition and those used for implantation. Obviously this is an over simplification of the processes. For example an inductively coupled etch plasma using Cl₂ as the feed gas is clearly different than a capacitively coupled deposition plasma using silane. However, there are some very similar aspects to both plasmas.

All process plasmas are similar in that the plasma source, gas-phase species and surfaces interact to make the whole system. Often the plasma is created and sustained through an electric or electromagnetic heating of electrons. A small fraction of the electrons gain sufficient energy to ionize the local neutral gas. In addition, these energetic electrons will dissociate and heat, often indirectly, the neutral gas. Eventually, the ions drop across a sheath to a surface that is in or which contains the plasma. Neutrals, both the initial and daughter species, also diffuse to these same surfaces. At this point, a wide number of processes can occur, with many of them occurring in combination. This includes neutralization of the ions and subsequent reflection of energetic neutrals into the gas phase. These fast neutrals may undergo chemical reactions which liberate new gas species, they may sputter new species into the gas-phase, or they may adsorb on the surface or may simply bounce off of surfaces. All of these processes depend on the type of surface, surface conditions and the make up of the gas impinging on the surface. In most process plasmas the principal gas-phase molecules are those that have interacted with the system surfaces. Because both the ion species and the electron energy distribution are determined in part by the gas-phase chemistry present in the system, we find a strong interaction between the plasma source, the gas-phase species and the surfaces. I, and many others, have found significant evidence that this view of process plasmas is correct. (Examples of this are given in my sample publications.) Thus, while the complex processes are not yet understood, this view of plasma process systems is widely held by researchers in this field.

I desire to understand these interactions through experimental investigation. I have developed a number of tools to pursue these studies. Primary amongst them is the use of Fourier transform infrared spectroscopy for the study of gas-phase chemistry in low-pressure, high-density plasmas. In addition, I have developed two novel plasma sources in which I can readily change plasma heating (source), gas-phase chemistry and most importantly the conditions of plasma facing surfaces. As such, I have developed experimental plasma systems that are almost as flexible as the computer simulations of process plasmas being developed elsewhere.

As a final tool in my experimental investigations, I team with other researchers who have skills that compliment my skills. (I know better than to think that I know everything.) An example of this is work currently underway with Larry Overzet. In this investigation we make experimental measurements in a highly versatile plasma system. By comparing our results to basic models, we believe that we can begin to develop a better understanding of the complex interaction in these plasmas.