Professor Grant Ritchie

Pasma Power: The Chemistry Behind Modern Electronics

Q: Are you concerned about the impact that the uncertainty around the future of Artificial Intelligence could have on your research?

A: Yes, but not necessarily negatively. For fields like plasma diagnostics, AI offers substantial opportunities including: real-time plasma control and optimisation, discovery of reduced-order models from large simulation datasets, faster interpretation of diagnostic measurements, more efficient exploration of multi-parameter complex plasma chemistries such as O_2/CF_4 or O_2/C_4F_8 systems.

Q: How do the techniques you use to measure electron density in artificial plasmas adapt when measuring highly reactive, ionized species in the upper atmosphere?

A: The underlying physics is the same, but the diagnostic strategy changes dramatically on moving from an artificial laboratory plasma to the highly rarefied, chemically reactive plasma of the upper atmosphere (ionosphere). In a laboratory plasma, especially the low-pressure ICPs and electronegative plasmas that are used in the semiconductor industry, electron density is often measured directly using intrusive diagnostics such as Langmuir probes, microwave techniques (such as the resonance probe method introduced in the talk), or optical methods. Upper-atmospheric plasmas present a very different environment: electron densities are much lower, collision frequencies are lower, the plasma extends over hundreds of kilometres, and access is only possible via rockets, satellites, or remote sensing. As an example, rather than sending microwaves through a vacuum chamber, researchers transmit radio waves through the ionosphere and measure: phase delay, reflection height, and plasma resonance frequencies. The last of these yields the electron density.

Optical emission spectroscopy may also be used and in these cases auroral emissions become valuable. Emissions from electronically excited O atoms (at 630.0 nm and at 557.7 nm), N2+ and O2+ can be modelled using collisional-radiative kinetics to infer local electron densities and temperatures. Thus, the emphasis shifts from direct density measurement to density retrieval through atmospheric chemistry models.