The Fundamentals of Glow Discharge Optical Emission Spectrometry and Implications for Proper Instrument Design

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Glow discharge spectrometry (GDS) has become an important tool in both academic and industrial laboratories, where it has been utilized effectively to analyze an extremely broad range of material types from electrically conductive solids, including all forms of iron and steel, aluminum, brass, copper, lead, tin, zinc, nickel as well as stainless steels and other highly alloyed corrosion resistant materials. As such, GDS has proven to be a very capable "bulk" analysis technique but surface analysis, also known as quantitative depth profiling (QDP) or compositional depth profiling (CDP), is where GDS excels. Unfortunately, the instrumental requirements for CDP applications are somewhat more challenging than that of bulk analysis. Non-conductive materials are analyzed using the radio frequency glow discharge (RF-GDS). An even broader realm of samples, many of which are thermally labile, are also accessible using RF-GDS. Layered combinations of almost all of these materials can also be analyzed by CDP. Clearly, designing appropriate instrumentation to analyze this vast array of applications and materials is no simple task for the instrument designer.

So where does the instrument designer start when conceptualizing a new GD spectrometer system? What are the appropriate questions and requirements for such an instrument? And how, as instrumental scientists, do we get the answers to these questions? The simple but nontrivial answer is that we must go back to basics. We must consider the fundamentals. We need to approach these questions in light of the analytical requirements of the sample(s), asking questions such as: What are the fundamentals of bulk GD analysis? How do the fundamentals and requirements of CDP differ from bulk analysis? What acquisition rates are required for near-surface analysis? What are the instrumental requirements of nonconductive samples? How do thermally labile materials impact these requirements? What are the typical photon fluxes and temporal behaviors encountered in the various applications? What wavelength range is required to analyze most if not all glow discharge samples? How do we best collect, focus, sort, detect and manipulate such analytical signals?

This presentation will focus on these design questions in detail. The raw data from which such instrumental design decisions are made will be presented and analyzed. Various instrumental approaches will be compared and contrasted. Typical trade-offs and compromises will be discussed. Examples of appropriate instrumental solutions will be provided.