

Abstract

The analytical technique based on inductively coupled plasma combined with optical emission spectrometry (ICP-OES) is widely used in elemental analysis due to its high sensitivity, selectivity, and resolution. These characteristics enable both, qualitative and quantitative analysis of elements present, for example, in environmental and food samples. However, the application of ICP-OES is associated with high operating costs, including the consumption of large volumes of ultra-pure plasma gas (for example, argon), high electrical energy demands, and the need for regular authorized servicing. As a result, ICP-OES is not commonly accessible, and the purchase of ICP-OES instrumentation is often economically unjustified for smaller research laboratories.

Another important aspect of ICP-OES instrumentation is its size, which limits its mobility and prevents the possibility of conducting in situ measurements. This introduces additional stages into the sample analysis process, thereby increasing analysis time and potentially negatively affecting the obtained measurement results. One possible solution to these challenges is the miniaturization of plasma excitation sources for applications combined, for example, with optical emission spectrometry (OES). In recent years, this topic has attracted increasing interest within the scientific community. The developed plasma microsystems are often significantly less complex in terms of design, less expensive, and portable, however, they still suffer from certain limitations and imperfections, such as operational instability or susceptibility to failure.

This doctoral dissertation serves as a guide to a collection of four scientific publications describing the possibilities and challenges associated with the miniaturization of plasma sources and their practical application in the analysis of environmental and food samples. The presented studies integrate miniature plasma sources with OES and employ techniques such as chemical and photochemical vapor generation (CVG, PCVG), hydride generation (HG), and the preconcentration of volatile analyte species by gold trapping (GT). Furthermore, high-voltage direct current, alternating current, and pulsed current power supplies, as well as portable power sources, were investigated. The conducted studies enabled the systematization of factors influencing the analytical signal, thereby contributing to the advancement of miniature plasma-based analytical methods utilizing OES. The described works aimed to demonstrate the practical applicability of the developed systems and to present real engineering challenges encountered at various stages of their development.