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Atmospheric pressure discharge plasma - atomic emission spectroscopy used for elemental analysis

Hao Yuan[1], De-zheng Yang[1], Jie Zhang[1]
[1] Key Laboratory of Materials Modification by Laser, Ion, and Electron Beams (Dalian University of Technology), Ministry of Education, Dalian 116024, China
e-mail: yuanhao@dlut.edu.cn

Elemental analysis is a technique used to determine the elements and their content of sample, which is widely applied in deep space exploration, geological exploration, environmental monitoring.[1] The most common method of elemental analysis is ICP-AES/MS, which has a good detection stability and sensitivity. However, ICP-AES/MS is only suitable for operating in laboratory, and cannot be used for in-situ elemental analysis, because it cost much inert gas, can only detect liquid sample, and have the high energy consumption. Recently, LIBS was introduced into elemental analysis, which can detect solid sample, and don't need special gas.

The basic principle of ICP-AES/MS and LIBS for elemental analysis is atomizing the tested element in the sample by the high temperature and particle bombardment of plasma, and the generated atoms are excited or ionized, and the excited atoms or ions are detected by the emission spectrometer or mass spectrometer.[2] Based on this process, atmospheric pressure discharge plasma can also be applied for elemental analysis in theory. It presents a great potential in portable use, rapid detecting and in-situ analysis, depending on its advantages of simple operation, low cost of equipment, and miniaturization of devices.[3]

However, similar with ICP-AES, atmospheric pressure discharge plasma was mainly used for detecting liquid sample. It is because that metallic elements usually exist in liquid in the form of ions. However, solid samples have a more stable structure and lower chemical activity, and metallic elements exist in the form of crystals, so it is more difficult to be atomized, requiring plasma with higher gas temperature, more energy injection and more abundant active particles.

In our studies, the metallic elements both in liquid and solid were detected by pulsed electrolyte cathode discharge, atomization discharge and needle-needle bare electrode arc discharge. The detecting limits of Cd, Cu, Fe and Pb were measured, in the level of 0.01 μg/mL in liquid sample, and in the level of 0.01 μg/g in solid sample. Importantly, temporal resolved spectra were employed to filter spectral interference, which are mainly sourced by the spectral bands of OH ($A^2\Sigma$–$X^2\Pi$) and N_2 ($C^3\Pi_u$–$B^3\Pi_g$). As a result, the detection sensitivity of elemental analysis was improved significantly.

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References

[1] J.R. Bacon, *et al*, J. Anal. At. Spectrom. **38**, 10 (2023).
[2] S. Mushtaq, *et al*, J. Anal. At. Spectrom. **37**, 985 (2022).
[3] P. Pohl, *et al*, TrAC Trend Anal. Chem. **88**, 119 (2017).

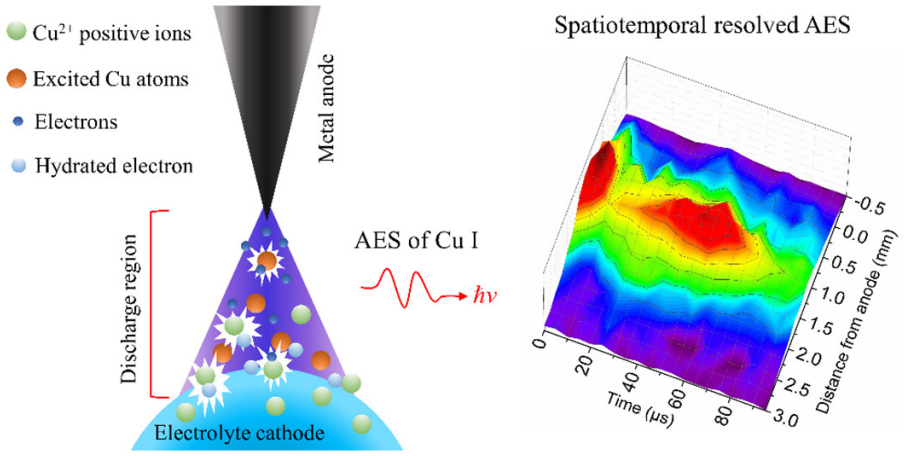

Figure 1. The schematic diagram of pulsed electrolyte cathode discharge – atomic emission spectroscopy used for elemental analysis.