Prototype Coded Aperture Miniature Mass Spectrometer using a Cycloidal Sector Mass Analyzer, a Carbon Nanotube Field Emission Electron Ionization Source and an Array Detector

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The size and cost of conventional mass spectrometers have limited their use in field applications. Miniaturization has been limited by the tradeoff between throughput and resolution. Recently, a solution to this tradeoff has been demonstrated by using spatially coded apertures in magnetic sector mass spectrometers, including a simple 90-degree magnetic sector and the double focusing Mattauch-Herzog sector geometry. However, the 90-degree sector has limited mass range, while the fringing fields lead to relatively poor aperture imaging in the Mattauch-Herzog MS. This paper demonstrates the compatibility of aperture coding with the cycloidal mass analyzer using both finite element simulations and an experimental miniature prototype cycloidal coded aperture miniature mass spectrometer (C-CAMMS). C-CAMMS incorporates aperture coding, a new magnet geometry with improved field uniformity, a miniature carbon nanotube (CNT) field emission electron ionization source, and a capacitive transimpedance amplifier ion array detector. The C-CAMMS prototype instrument is 20 x 20 x 8 inches and weighs approximately 40 lbs. Simulations indicate that to achieve accurate coded aperture imaging in a cycloidal mass analyzer, the electric and magnetic fields must be uniform to within 1% over the ion trajectories. Experimental results from the C-CAMMS prototype instrument confirm the cycloidal mass analyzer's compatibility with aperture coding. After coded mass spectra reconstruction, a >10x increase in throughput was achieved without loss of resolution when compared to a single slit instrument. Several opportunities for both improving the system resolution and reducing the size and weight will be discussed.

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