A CCD Detector Array for Direct Ion Measurement

Gottfried Kibelka, OI Analytical/CMS Field Products, Pelham, AL

A non-scanning miniature Mass Spectrometer of Mattauch-Herzog geometry was previously developed and is now used in our research efforts towards a detector for the direct and simultaneous measurement of a complete mass spectrum. The miniature Mattauch-Herzog instrument delivers a spatial separated stream of ions of different mass. To fully take advantage of the high duty cycle of a sector field instrument, a detector or array of detectors with high spatial resolution is needed. Available detector arrays which convert ions into electrons prior to detection (for example, electro-optical ion detectors or combinations of multichannel plates and anodes) face the challenge of being close to the exit of the magnet and therefore in the focal plane of the mass spectrometer but at the same time being far enough away to reduce the interference between the magnetic fringe field and the low momentum electrons, which usually results in low resolution. The best approach is to directly measure the ions in the focal plane. The charge-coupled device (CCD) is well understood and is widely used for photon detection. By utilizing basic CCD designs, a modified CCD capable of ion detection was developed. The most important step was the replacement of the photon sensitive part with a metal-oxide-semiconductor (MOS) capacitor. The MOS capacitor collects ions, and the charge can be clocked out and displayed as signal intensity over mass. The CCD is operated in a "spill-and-fill" mode to provide high linearity and to minimize signal interferences. The ion-CCD has been fabricated in a one-inch, 1286-pixel version and in a two-inch, 2598-pixel version. The high spatial resolution of the CCD detector provides – even in the miniaturized magnetic sector instrument – mass spectra with better than 1-amu resolution. Frame readouts of 1kHz have been demonstrated, and the optimization of the detector reading yields complete mass spectra at 10-100Hz.