Charged Particles for Emerging Interdisciplinary Applications

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Significant progress has been made in the science and technology of charged-particle sources, beam extraction, transport and focusing, especially in the context of generating high-brightness beams for high-energy particle accelerators and magnetic fusion devices [1,2]. Activities pertaining to emerging interdisciplinary applications have been steadily growing, and a vast domain encompassing semiconductor devices, space sciences, biological and medical sciences, and above all, screening for contamination and regulated substances can be noted. Examples include: tailoring ions to modify surfaces and generate new materials; developing fine-spatial scale (~nanometer or smaller) probes to extract information from targeted regions in materials, especially, in soft materials pertaining to biological entities and often exploiting maps of chemicals to understand critical diseases; exploiting reaction chemistry through Ion Mobility Spectrometry and building novel sensors for trace-materials detection [3-7]. Negative ions own special merits in many applications because of its merits for self-regulation of charging, especially for interactions with electrically insulating materials [8]. In contrast to applications requiring vacuum environments, e.g., materials processing, surface analysis by secondary ion mass spectroscopy (SIMS), ion beam lithography and semiconductor device inspection, a distinct need constitutes formation of ions and ion transport in ambient environmental conditions for IMS [7]. Ions from an atmospheric pressure ionization source diffuse through a counter-streaming neutral background in an IMS drift cell; a uniform axial electric field across the drift cell governs ion trajectories. Along with broad discussions of different applications and distinct characteristics of ions this talk will attempt to dwell on key physics issues related to effectively capturing ions from sources and manipulating these ions to achieve targeted objectives. Two unique cases will be highlighted: one is IMS and the other is SIMS imaging. The complexities and underlying challenges, especially related to space-charge problems, will be discussed in the context of IMS miniaturization, a major thrust area in current activities [9-12]. Several applications of IMS, especially, detection of trace materials for security screening, critical disease detection, and contamination will be illustrated. This talk will then highlight an overarching need for high-brightness ion beams and associated transport and focusing in the context of SIMS imaging [5]. Its relevance to several cross-cutting applications will be discussed.

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