Flexible Ion Optics: 3D-printed Cylindrical Analyzers  
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Abstract

We investigated the application of 3D-printed electrical analyzers under high vacuum conditions. While electrical analyzers are a common tool in vacuum physics, little has been done to explore the use of plastics as deflection and ion-optics devices. The introduction of printable conductive plastics to ion physics allows us to explore ion interactions quickly and cheaply. In this experiment we explored the effectiveness of conductive polylactic acid (PLA) as a cylindrical electrical analyzer for sodium ions. Our experimental setup was modeled in SIMION, an ion and electron simulation program.

Background

A previous study by P.R. Johnson et al. [1] showed that conductive PLA maintains structural integrity under high vacuum applications and also has the ability to hold appreciable capacitance. The study demonstrated that a charged plate of conductive PLA can deflect an ion beam. We further their work by utilizing more complex geometries of our printed material.

Procedure

3D printing:
- 18 and 25 mm walls printed on a bed of High Impact Polystyrene (HIPS) using Lulzbot Taz 5 (Aleph Objects, Inc.)
- Atmospheric exposure limited through use of dessicant storage

Vacuum preparation and beam test:
- Cylindrical analyzer wired, placed in main vacuum chamber
- 12-24 hr pump down cycles, pressures of ~10^-7 Torr
- Beam energy of 1000eV

Results

SIMION:
- 21 Particles shot 0.1 mm from each other
- No ion interaction

<table>
<thead>
<tr>
<th>Input Beam Energy (eV)</th>
<th>R₁ (V)</th>
<th>R₂ (V)</th>
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<tr>
<td>300</td>
<td>0</td>
<td>115</td>
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<tr>
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<td>331</td>
</tr>
<tr>
<td>1000</td>
<td>0</td>
<td>381</td>
</tr>
</tbody>
</table>

Table 1: R₂ voltage for maximum beam current based on input beam energy

Fig. 3: XY view of simulated ion trajectories

Fig. 2:
- Ion beam size reduced by grounded exterior shim
- Grounded shielding shim protects ion beam from stray electric fields
- Current optimized at entrance plate using ion source deflector plates
- Current optimized at exit plate by adjusting V₁ and V₂ values

Future Work

- Make systematic measurement of transported beam current within analyzer path
- Develop and test more ion-optics devices, i.e. Einzel lens

Acknowledgements

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References