CLEANING DIELECTRIC SURFACES BY THE ELECTRICAL FIELDS OF THE LINEAR ELECTRODYNAMIC PAUL TRAP

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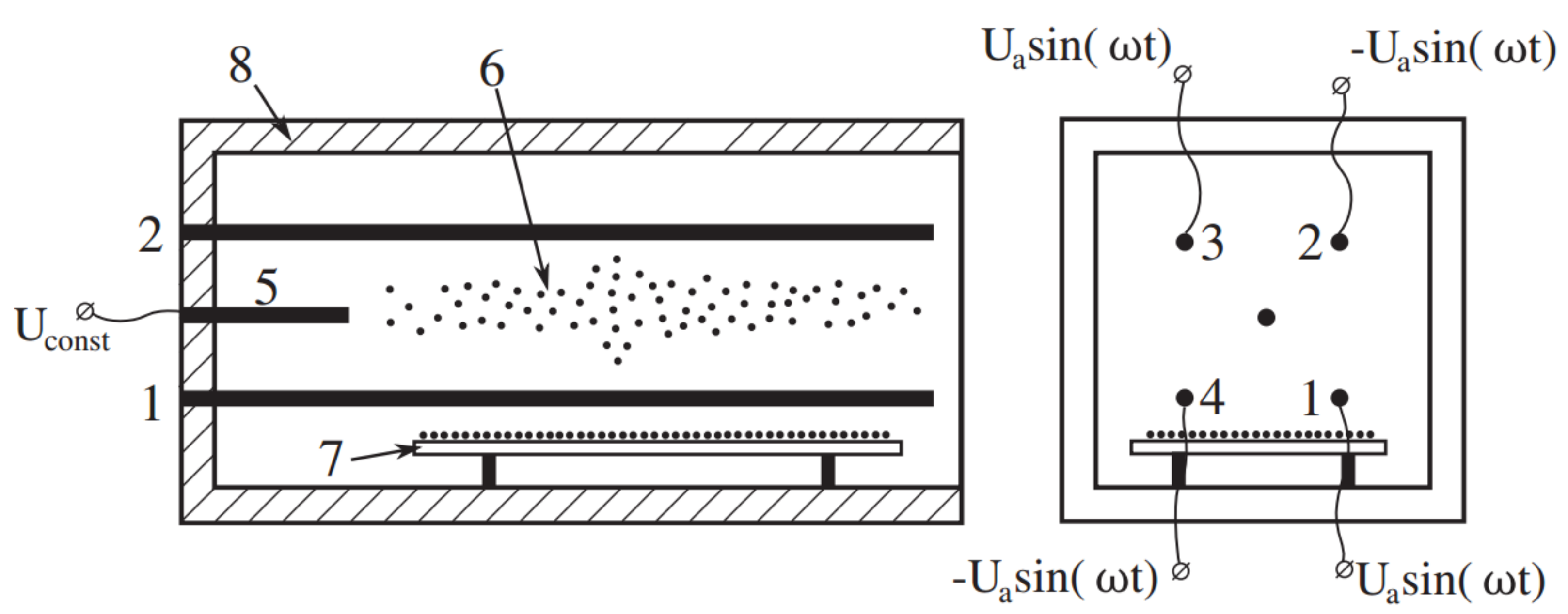
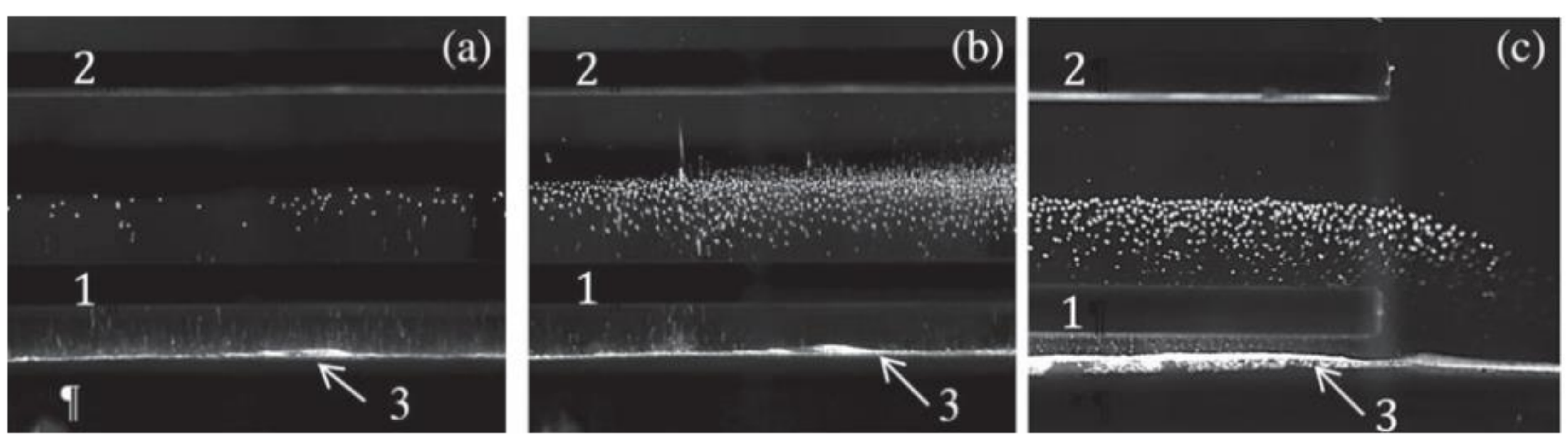
A method against dust pollution of dielectric surfaces has been proposed. The dust removal is achieved applying alternating electric fields of special geometry created by the linear electrodynamic Paul traps, which polarize dust particles on the surface of the dielectric and draw them into the interelectrode space of the trap. The captured dust can be contactlessly moved toward the electrodes ends in a special container by an additional constant electric field. The feasibility of the approach was demonstrated by a series of experiments on the contactless removal of aluminium oxide and sand particles of various sizes from a glass surface and solar panels. The capture of a single particle was analyzed using numerical simulations and the conditions necessary for its capturing and levitating were determined.

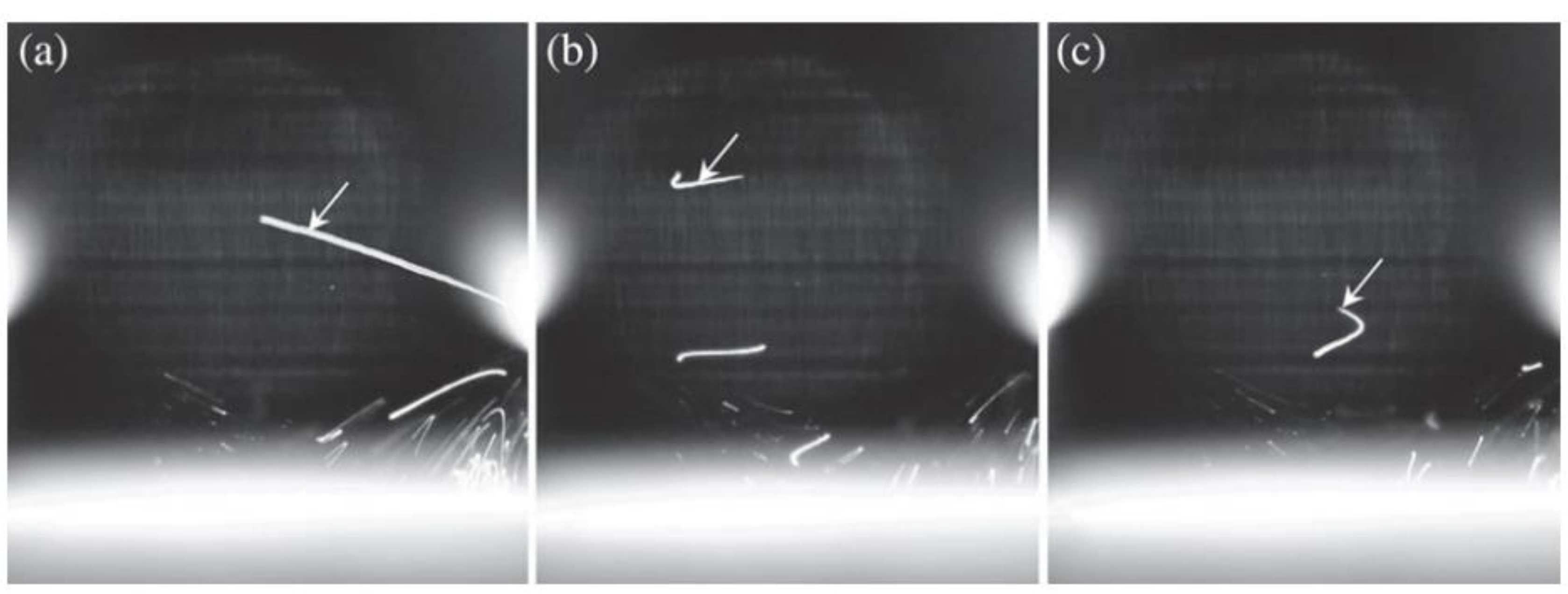
Experiments



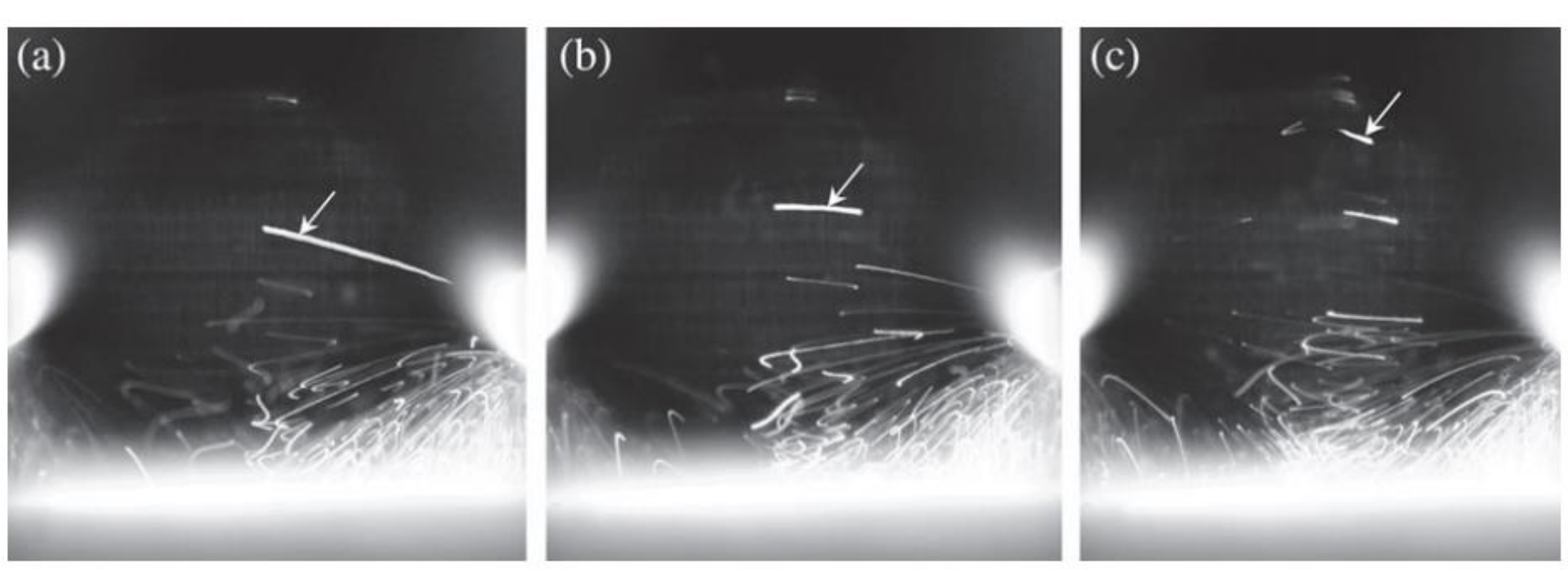
Scheme of the trap, front and side views. *Notations*: 1–4—the electrodes of the trap, 5—the end electrode, 6—the confined particles, 7—glass substrate with dust particles, 8—optically transparent plastic box.



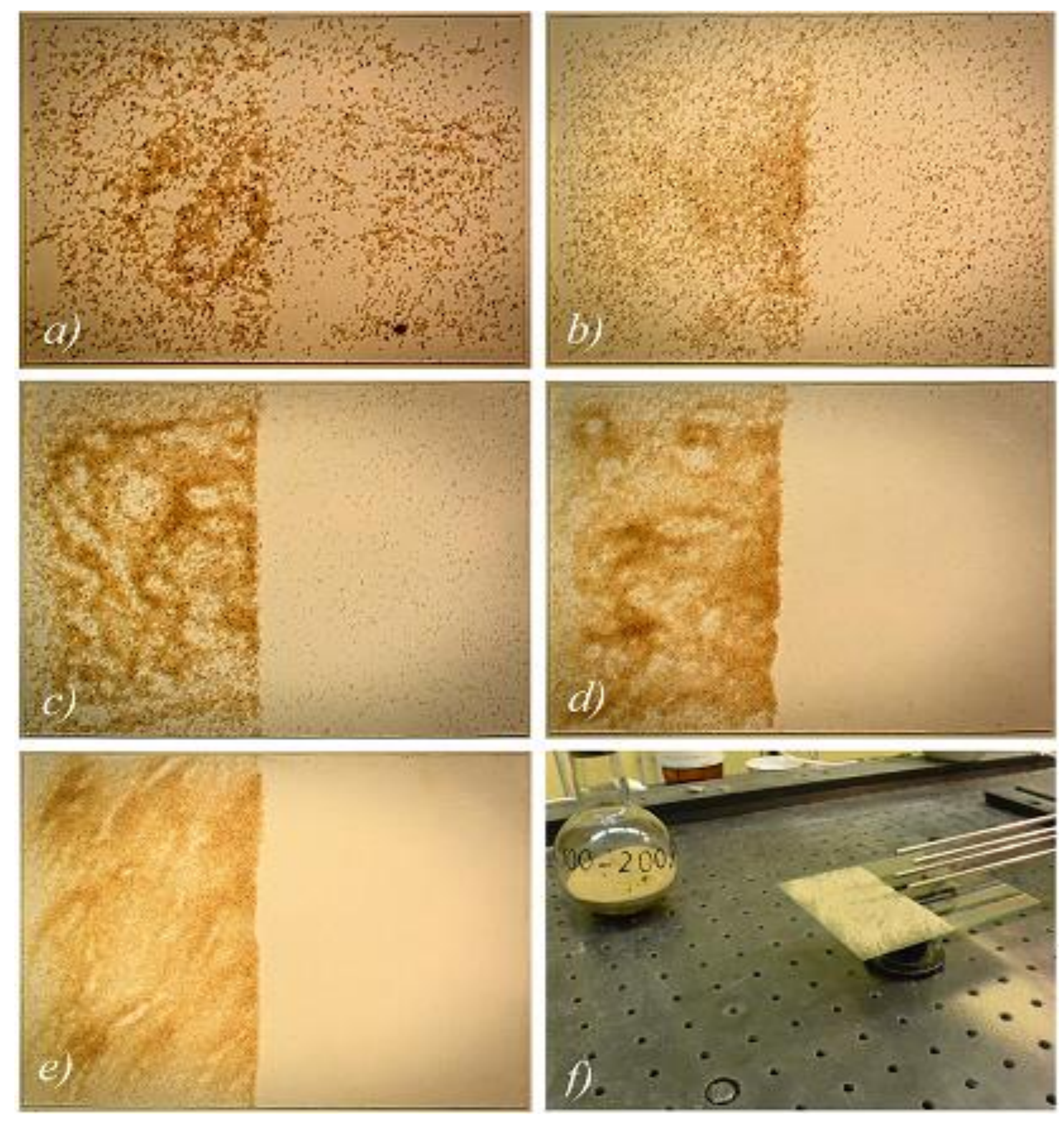
Images of Al2O3 particles drawn from the glass substrate located at a distance of 0.5 cm from the electrodes of the trap at different voltage amplitudes: (a) *Ua* = 3.5 kV, (b) and (c) *Ua* = 5 kV; 1 and 2 are the trap electrodes, 3 is the glass substrate with the particles.



The trajectory of the particle (marked by an arrow) at a electrode voltage amplitude *Ua* = 2.5 kV, which is insufficient for confinement; (a) t = 0 s, (b) t = 3T, (c) t = 6T, where T = 1/50 s.

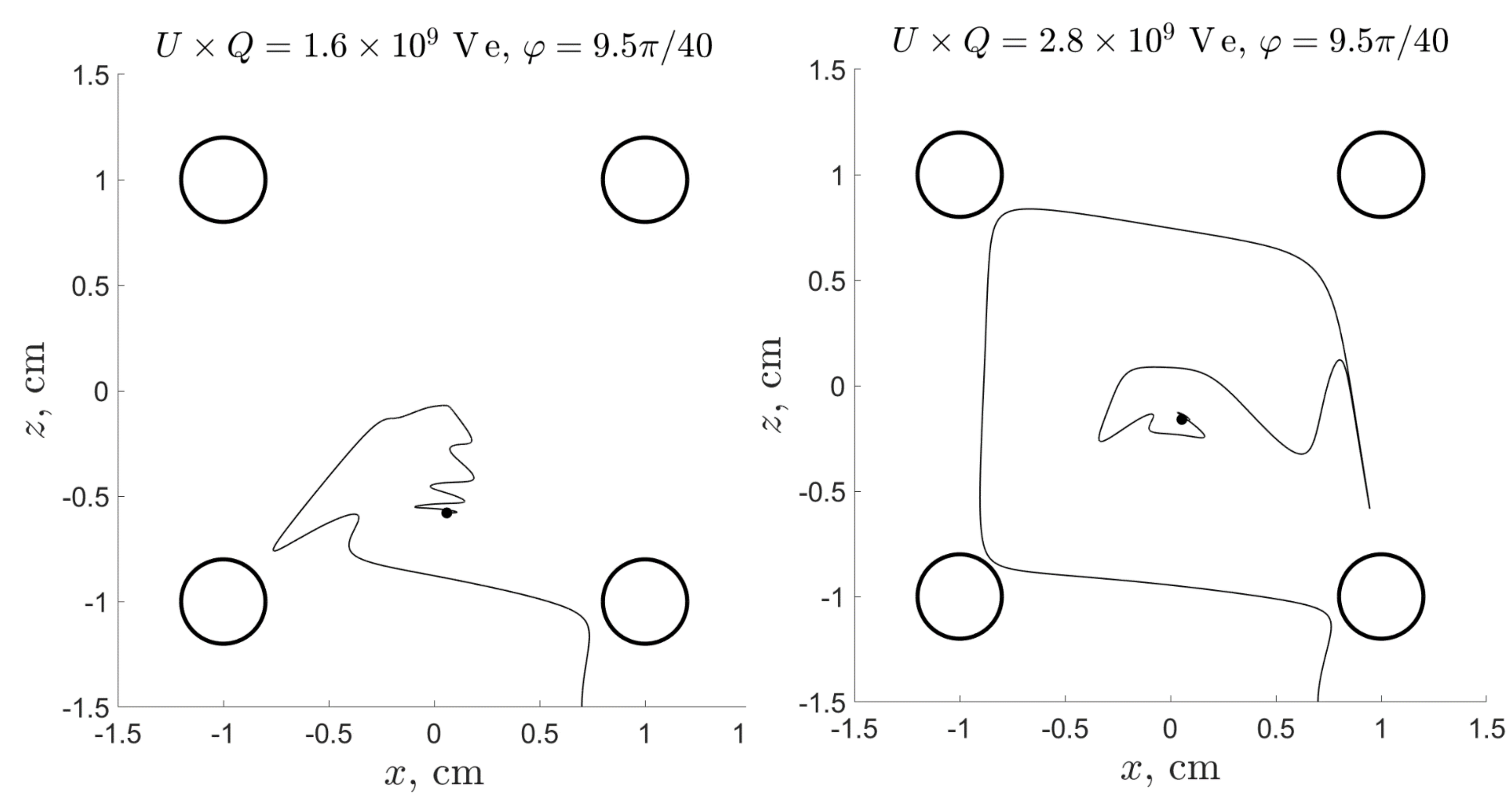


Trajectory of the confined particle (marked by an arrow) at the voltage amplitude *Ua* = 3.5 kV. The particle moves to the center of the trap; (a) t = 0 s, (b) t = 3T, (c) t = 6T, where T = 1/50 s.

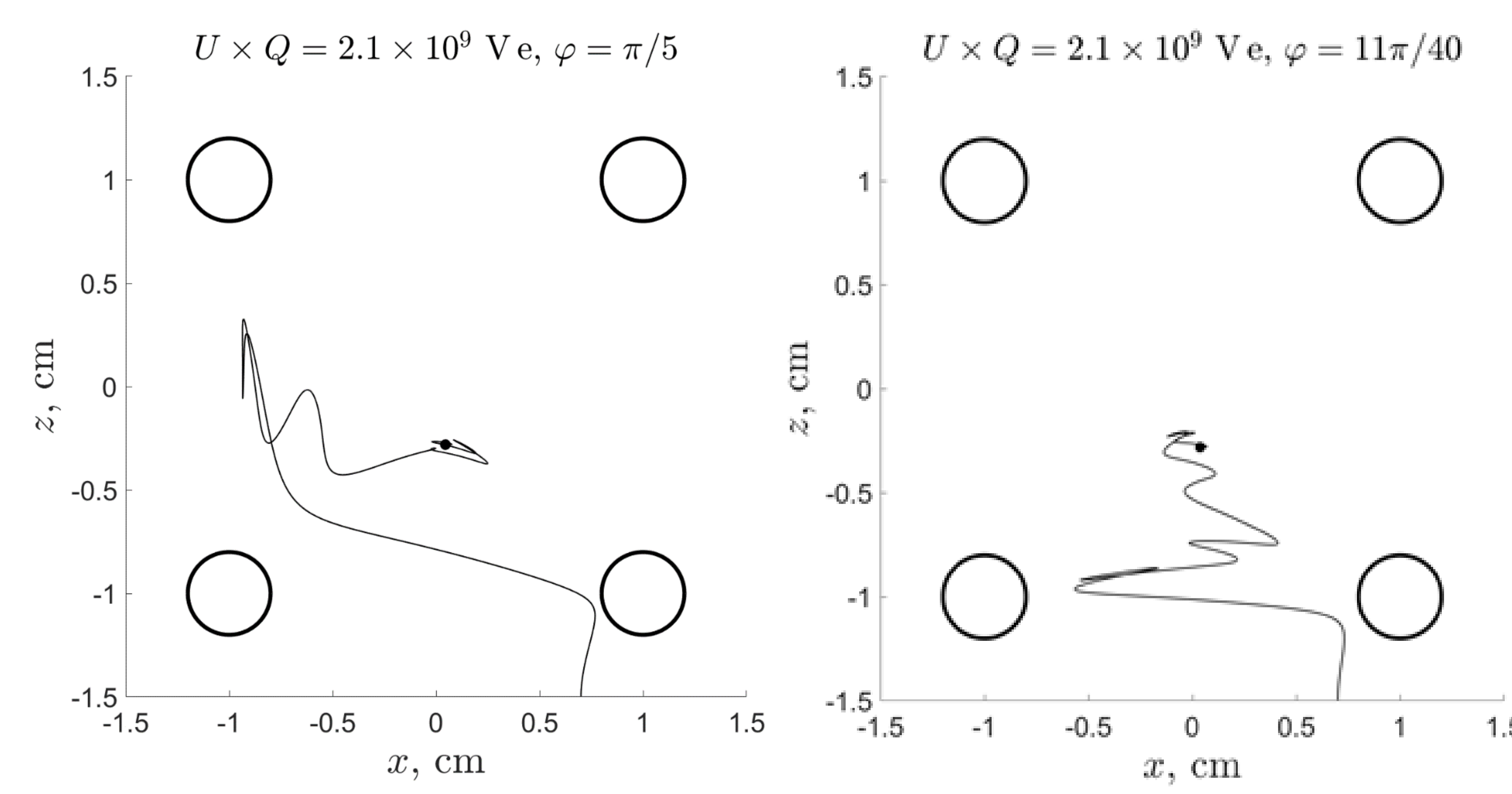


The right part of the glass substrate was cleaned by the linear Paul trap. The dirty left part of it has been polluted by the particles of quartz sand of various sizes(images: (*a*) - *d* > 400 μm, (*b*) - 280 μm > *d* > 400 μm, (*c*) - 200 μm > *d* > 280 μm, (*d*) - 100 μm > *d* > 200 μm, (*e*) - *d* < 100 μm). Image (*f*) shows the experimental setup.

Simulations



Particle trajectories at boundary values of $U \times Q$ (1.6×10^9 *Ve* for left panel and 2.8×10^9 *Ve* for right panel) and a fixed value of the initial phase $\varphi = 9.5\pi/40$.



Particle trajectories at boundary values of initial phase φ ($\pi/5$ for left panel and $11\pi/40$ for right panel) and a fixed value of $U \times Q = 2.1\times10^9$ *Ve*.

Conclusion

We have demonstrated the possibility of cleaning dielectric surfaces including solar panels from dust particles using an electrodynamic trap located at a small distance from surface and moved along it. In the experiments, polydispersed alumina powder and silica sand sifted through sieves with a mesh size of 400, 280, 200 and 100 μm have been used. It was shown that the cleaning method proposed effectively copes with the removal of sand particles smaller than 200 μm in size from a horizontal surface. Through numerical simulation, the capture of a single particle has been analyzed. For a particle of a specific size, the range of product $Q \times U$ necessary for its capture and levitation have been found.

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