1. Abstract

Charged colloidal particles in nonpolar liquids are a basic ingredient for electrophoretic displays. In these displays charged and colored particles move under the influence of an electric field in order to change the optical state of a display pixel. Understanding the origin of the charge of these particles and their electrokinetic motion in the display pixel forms a challenging problem. Here, an overview is given of different techniques for particle manipulation using electrical fields, and for measurements of particle properties with high accuracy, based on optical microscopy. These techniques are used to study charging mechanisms of particles, particle trajectories in in-plane switching devices and fundamental electrokinetic phenomena such as the electrophoretic retardation effect.

2. Optical setup

Basis: Nikon Eclipse Ti with triggered image acquisition from an Andor EMCCD camera and multiple synchronized analog outputs

Advanced image analysis and microscope control with custom made Labview program

wavegenerator + 12 analog outputs

image analysis:

x,y,z position

3. Particle tracking

The x,y,z position is calculated from the intensity centroid and from comparing the radial intensity profile with a library of profiles obtained with a z-stack.

4. Electrical trapping

3D particle control using active electrical feedback in a device with electrodes in octupole configuration

A single particle is forced to create a knot:

device with 8 electrodes for electrical trapping:

5. Charge measurements

By analyzing the particle motion as a result of an electric field, the particle charge is measured

measurement of discrete charging events on a single particle:

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measurement of long term charging dynamics using an AC field:

6. In-plane electrophoresis

The particle motion in in-plane displays is studied with simulations and measurements


simulations of the Poisson-Nernst-Planck equations:

Measurement of characteristic switching of pigment particles in an in-plane device:

7. Electrophoretic retardation

The electokinetic phenomenon in which the particle speed is reduced because of the countercharge in the double layer is measured directly

By applying a DC voltage, the countercharge in the double layer is stripped off and the particle mobility increases:

8. Conclusions

It is demonstrated that advanced image analysis and electric fields are a powerful combination for single particle manipulation and analysis. By applying electric fields particles are trapped and manipulated in 3 dimensions, and particle properties are measured even with elementary charge precision. This allows to study particle switching in displays, long term charging dynamics, and fundamental electrokinetic phenomena such as electrophoretic retardation.