Inkjet Printing of $LaNiO_3$ Electrodes for Ferroelectric Applications

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Minimizing the production costs is of upmost importance in modern electronic industry. Existing technology is mostly based on physical vapor deposition of functional layers and sequential etching by lithographic techniques, which can be difficult and may damage the layer. Inkjet printing has emerged as an alternative due to its unique features, such as cost- and time- efficient deposition of material without the need of any patterning steps. Yet, a high complexity of the printing process—extending from the jetting concerns to the issues connected with the morphology of dried deposit—has impaired the fabrication of electronic devices using inkjet printing.

Here we report a study on inkjet printing of conductive lanthanum nickelate (LNO)—a promising electrode material for applications in ferroelectric devices. The LNO inks consisted of lanthanum nitrate and nickel acetate dissolved in a mixture of organic solvents with different surface tensions and boiling points. Our results show that the morphology of dried deposits is critically dependent on the ink's solvent composition, wetting of the substrate, and drying temperature. These parameters appear to be interrelated in the drying process; well-defined structures with flat thickness profile can be printed only when all three parameters are optimized.

We further discuss the observed morphologies of dried features by considering the evaporation of multi-component inks and related variations in the solvent composition caused by different volatilities of the solvents present. Variations in the solvent composition induce changes in physical properties, which lead to the evaporation-driven internal liquid flows and sometimes also to the wetting transition. The internal liquid flows have already been suggested to strongly influence the deposit morphology, while the wetting transition (and the associated three-phase contact line movement) is generally unwanted and rarely reported in inkjet printing. We demonstrate how the wetting transitions can be exploited to boost the printing resolution beyond the limits set by the volume of the printed drop. The inks, which were designed to promote the inward contact line movement enabled a deposition of small electrodes with a diameter of only few micrometers.

Ferroelectric capacitors with inkjet-printed LNO electrodes on top of a Si/SiO_2/LNO/PZT stack showed good and reliable electrical performance, thus proving a high potential of inkjet printing in future production technology.