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Effect of Poly(4-vinylphenol) Concentration Increase on Deposition Rate of Dielectric Thin Film Fabrication by Using Electrohydrodynamic Atomization

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In this work, the effect of poly(4-vinylphenol) (PVP) concentration increase on electrohydrodynamic atomization and its deposition rate has been studied. The aim of this study is to further increase the deposition rate of uniform dielectric thin films by the nonvacuum electrohydrodynamic atomization process. The operating envelope has been explored by subjecting ink to controlled flow through a metallic capillary exposed to an electric field at ambient temperature. It has been observed that greater applied voltage is required to develop a stable cone jet from a highly concentrated PVP meniscus, in comparison with lower concentration. A combination of optimized parameters has been used from the developed operating envelope to generate an electrohydrodynamic jet, which subsequently disintegrated into droplets, thus depositing a uniform PVP thin film on indium tin oxide-coated polyethylene terephthalate substrates with average thickness of ~40 nm at constant substrate speed of 3 mm/s. The PVP thin film has been characterized by using scanning electron microscopy, x-ray photoelectron spectroscopy, and ultraviolet (UV)–visible spectroscopy.

Key words: Electrohydrodynamic atomization, dielectric thin film, PVP, ITO-coated PET, transmittance

INTRODUCTION

Organic thin-film transistors (OTFTs) are attracting intensive attention for their potential applications in flexible low-cost electronic circuits due to their light weight, low cost, and flexibility.[1,2] Gate dielectrics of polymeric nature are the most promising candidates for use in OTFTs because of their solution processability and low curing temperature.[3,4] As in a parallel-plate capacitor, the capacitance strongly depends on the dielectric layer's thickness; i.e., if the dielectric film's thickness is decreased, the capacitance increases.[5]

Use of poly(4-vinylphenol) (PVP) has been reported most frequently because of its better performance compared with other members of the family of gate dielectrics.[3–6] The gate dielectric cross-linked poly(4-vinylphenol) (C-PVP) is investigated mostly for fabrication of OTFTs due to its easy thin-film formation and excellent dielectric properties. There are two ways to enhance the capacitance while using a material as a gate dielectric. One way is to use a material with high dielectric constant value, and the other way is to use a very thin film of dielectric nature. Thin-film fabrication of PVP is easy, and it also offers excellent dielectric properties.[7] However, thin-film deposition of C-PVP has been regarded as requiring very high temperatures (above 175°C), rendering C-PVP unsuitable for dielectric thin-film deposition on various flexible substrates.[6,7] Also, the cross-linking reaction between PVP and the cross-linker has been reported to occur at high temperatures and to enhance the

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