

## Inkjetted Organic Transistors using a Novel Pentacene Precursor

Steven K. Volkman, Steven Molesa, Brian Mattis, Paul C. Chang, and Vivek Subramanian.  
Department of Electrical Engineering, University of California Berkeley,  
Berkeley, CA 94720-1770, U.S.A.

### ABSTRACT

Pentacene is one of the most promising organic materials for organic transistor fabrication, since it offers higher mobility, better on-off ratio, improved environmental stability, and better reliability than most other organic semiconductors. However, its severe insolubility renders it useless for the solution-based fabrication of electronic devices. Solution-based processing is the key to enabling ultra-low-cost circuit fabrication, since it eliminates the need for lithography, subtractive processing, and vacuum-based film deposition. Using a recently developed soluble pentacene precursor, we demonstrate the first inkjet-printed pentacene transistor fabricated to date. This is achieved using a substrate-gated transistor structure in conjunction with an inkjet-printed pentacene precursor active layer. After deposition, the precursor is converted to pentacene via heating, through the decomposition of the Diels-Alder product. As the anneal temperature increases above 120°C, performance increases dramatically. The process is therefore compatible with numerous low-temperature plastics. As the anneal time is increased to several minutes, performance likewise increases through increased precursor decomposition. However, exposure to excess temperatures or times tends to degrade performance. This is caused by morphological and chemical changes in the pentacene film. Optimization of the anneal process alone has resulted in the demonstration of transistors with an on-off ratio of  $>10^5$  and field-effect mobility of  $>0.01\text{cm}^2/\text{V}\cdot\text{s}$ , attesting to the great promise of this material.

### INTRODUCTION

Recently, there has been great interest in the development of printed organic electronics technologies, which are expected to see use in low-cost, flexible displays and disposable electronics applications. Given the tremendous postulated price-per-area cost advantage of printed technologies over the competing amorphous and polycrystalline silicon based technologies, all-printed displays are expected to have tremendous cost-performance advantages over their incumbent silicon-based counterparts [1]. Similarly, low-cost RFID tags, with cost points in the sub-one cent range, are also compelling application for printed electronics, since they may be used to replace UPC barcodes on consumer products, ushering in an era of enhanced consumer convenience and warehousing efficiency, through a realization of real-time price and product controls, automated inventory processes, and automated checkout.

All-printed circuit technologies are attractive for several reasons, with their main advantage being cost-related. They eliminate the need for most of the major cost points in semiconductor manufacturing, including the most expensive cost point – lithography. Printed electronics also eliminate the need for high-vacuum processing, including PVD, CVD, plasma etching, etc., all of which have major impacts on system cost. Additionally, printed electronic systems use an additive fabrication process, which reduces the waste abatement costs. Thus, they should result in a substantially reduced cost making them suitable for use in disposable consumer products.

Over the last ten years, there has been tremendous emphasis on the development of soluble organic semiconductors, suitable for printing. Much progress has been made in this regard, with









