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## Introduction

In recent years the development of polymer light emitting diodes (PLEDs) has been a widely studied area of research. With polymers as the active layer on a plastic substrate, it is possible to make flexible devices, making PLEDs particularly interesting. Our work focuses on the fabrication of stable, flexible PLEDs with a simple device configuration for military applications. Preliminary results of device efficiencies are reported.

## Motivation

Construct a large area flexible light emitting diode display with a simple device configuration for military applications

## Single Layer LED Device Structure

### Cathode

- Injects electrons.
- Low work function material that is evaporated under vacuum onto the polymeric layer.
- Choice metals include calcium, aluminum and magnesium/silver alloy.

### Organic Layer

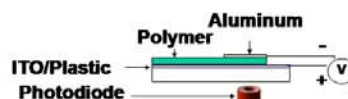
- Active conjugated layer that derives its semiconducting properties by having delocalized  $\pi$  bonding and  $\pi^*$  anti-bonding orbitals.

### Anode

- Injects holes.
- High work function material.
- Designed so that emission from organic layer can escape. Indium tin oxide is typically used.

### Device Characteristic

- Typical rectification behavior.



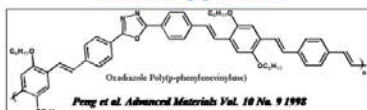
## PLEDs- Advantages

- ♦ Good luminescence efficiency
- ♦ Low operating voltage
- ♦ Full color potential
  - ♦ Vary the color of the emitted light by changing the structure of the polymer or varying the conjugation length.
- ♦ Thin, flexible structures
  - ♦ May be integrated into an all polymer based device.
- ♦ Low cost, solution processible techniques

## PLEDs- Challenges

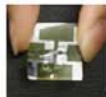
- ♦ ITO quality on plastic substrates is poor.
  - ♦ Holes are not always injected into the active polymer layer efficiently.
  - ♦ Consequently, additional hole transporting layer may be incorporated.
    - ♦ A layer of Poly-3,4-Ethylenedioxythiophene, PEDOT, is deposited onto the ITO/plastic layer. PEDOT is a conjugated polymer which can assist with the hole injection.
- ♦ Recombination of carriers can generate heat instead of light
- ♦ Encapsulation
  - ♦ Existing techniques involve metal layers but are expensive and not always effective.
- ♦ Quenching of luminescence
  - ♦ Oxidation of polymer may lead to quenching of luminescence and result in poor device efficiency.

## Initial Approach



- ♦ Use a PPV containing oxadiazole moieties along the backbone
- ♦ This polymer is oxidatively stable and provides good electron injection/transport because of the oxadiazole moiety
- ♦ Fabricate a single polymer layer device on ITO/plastic with Al

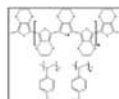
**Burning of plastic occurred due to generation of heat.**



## Solution- Improve Charge Balance

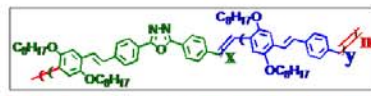
### Construct a Multi-Layered Device

- ♦ Introduce layer of PEDOT—a hole transporting species between the ITO and Active polymer layers.



poly[3,4-(ethylenedioxy)thiophene] poly(styrenesulfonic acid) (PEDOT)

- ♦ Change the structure of the active polymer layer and use a polymer that transports electrons and holes more equally.
- ♦ Use a random copolymer which on average is 70% OXAPPV monomer and 30% PPV monomer.



Random Copolymer on average 70% OXAPPV and 30% PPV

## Modified Approach

Device Configuration	Efficiency (%)	Turn-on Voltage (V)
Glass/ITO/Active layer/Al	0.010	5-6
Glass/ITO/PEDOT/Active layer/Al	0.012	5-6
Plastic/ITO/PEDOT/Active layer/Al*	0.007	4-5

\*Even at the application of 15 V, the plastic did not exhibit deformation due to burning.



## The Road Ahead...

- ♦ Incorporate a Lithium Fluoride electron transporting layer to improve device efficiency
- ♦ Fabricate devices using different metal cathodes such as Ca and Au
- ♦ Fabricate large area device
- ♦ Attempt to encapsulate devices

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