All Polymer Micropump using conductive polymers -

Utilising a micropatterned PEDT/PMMA blend

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Introduction

The ability to control chemical processes on the micrometer scale has many interesting perspectives and is a field in fast expansion. One of the main issues when dealing with microsystems is the pumping of fluid. The asymmetric AC electroosmotic pump (ACEO) was first suggested by Ajdari[1]. The pump consists of an array of asymmetric electrodes in a channel with an AC potential between the electrodes. This is presented in figure 1. The advantages of the pump are the simple construction, no moveable parts and low potential (1-5 V) requirements. This pump has been fabricated using a conductive blend of PEDT and PMMA as the electrode material.

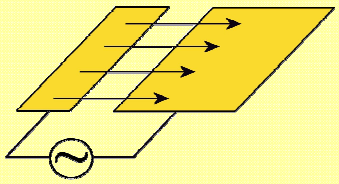


Figure 1) *The AC electroosmotic micropump consist of a small and a large electrode with alternating potential. Due to the asymmetric field the ions in the fluid move either toward the small or the large electrode. The direction is governed by the frequency. The moving ions applies a frictional force on the fluid – generating the pumping effect.*

Making the PEDT/PMMA blend

Recent research[2] has shown that the conductive polymer poly-3,4-ethylenedioxythiophene (PEDT) (figure 4) can be produced with a relatively simple method and have conductivity up to 1000 S/cm. The PEDT is however limited by a poor adhesion to substrates and poor scratch resistance - especially in aqueous environments. By making a blend of a PEDT and a none-conductive polymer like polymethylmethacrylate (PMMA) it is possible to produce a coating with good mechanical and electrical properties.

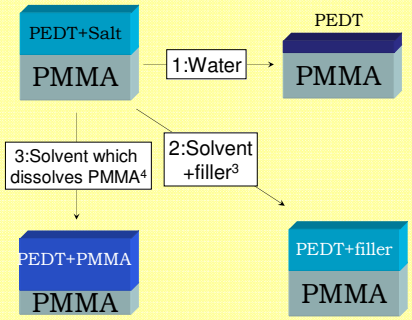
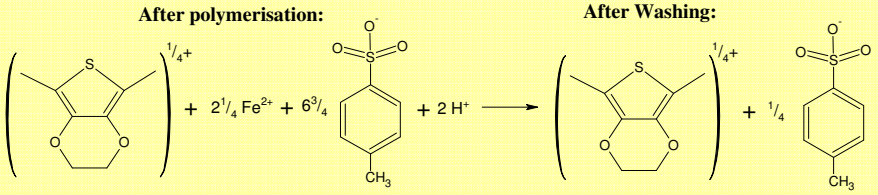


Figure 2) *The PEDT film with residual salt from the oxidation can either be washed with 1) water to yield a pure PEDT film – 2) with solvent + filler to yield a PEDT/filler film – or 3) with a solvent that dissolves the substrate (PMMA) and integrates the PEDT into the PMMA*

After polymerisation: **After Washing:**



The conductive polymer is produced from a butanol solution with ethylenedioxythiophene, Iron (III) Tosylate and pyridine. A thin layer of the solution is applied to a substrate and heated to 60 ºC, which evaporates the solvent and initiates the polymerization. After the polymerisation the polymer film consists of 90 w% residue salt from the oxidation. This has to be removed by washing and as the film collapses it is possible to trap macromolecules in the PEDT structure[3]. By choosing a washing solvent which dissolves PMMA the top layer of the PMMA is trapped in the PEDT during the collapse. With the used parameters a composition of 1:2 PEDT:PMMA was achieved.

Fabrication of PEDT patterns

The PEDT/PMMA structure was micropatterned using classical photolithography known from the electronic industry (see figure 3 and 4). The channel system was constructed using polyurethane and bonded to the PMMA substrate. The pump has been tested for a number of frequencies and shows capabilities of pumping in both directions with a velocity up to 200 µm/s.

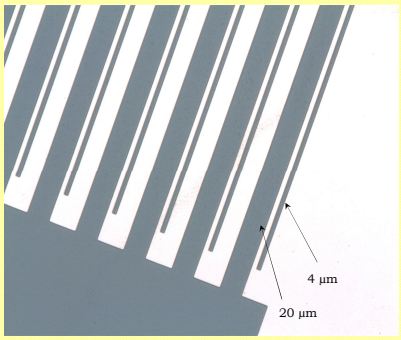


Figure 4) *The micropump constructed in PEDT/PMMA, with features down to 4 µm.*

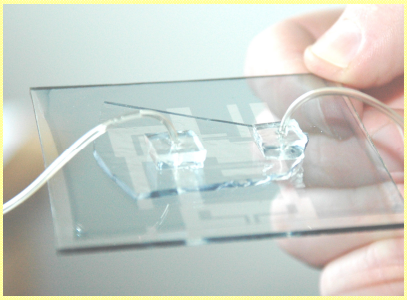


Figure 5) *The final micropump.*

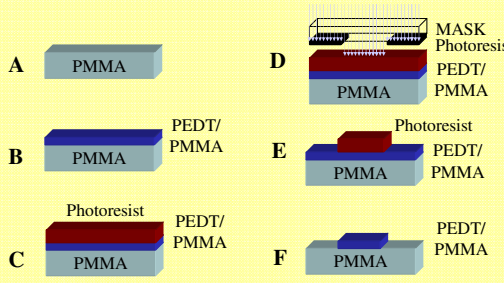


Figure 3) A+B) *A PEDT/PMMA blend is created on a PMMA substrate.* ***C+D)*** *The PEDT/PMMA is coated with photoresist and exposed with UV-light.* ***E)*** *The photoresist is developed.* ***F)*** *the device is etched in a reactive ion etcher yielding the final structure.*

References

1. A. Ajdari, *Physical Review E*, 2000, **61**, 45;
2. B. Winther-Jensen And K. West, *Macromolecules* 2004, **37**, 4538-4543;
3. B. Winther-Jensen et al, *Polymers* 2005, 46, 4664 – 4669;
4. Thomas Steen Hansen et al, Submitted for Synthetic Metals.

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