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Component

Flexible Parylene Based Sensors for pH and Gas Detection

Fast Facts

- High bendability by ultra-thin, biocompatible Parylene substrate
- Parylene as a versatile packaging platform for scalable production of miniaturized flexible sensors
- Direct integration of sensors for pH and gas monitoring on Parylene
- High sensitivity of the realized flexible sensors with 65mV/pH (pH sensor) and a detection limit of only 100 ppm (gas sensor) demonstrated

General Description

For the realization of smart systems as well as for enabling applications such as the Internet of Things and Industry 4.0, sensors and electronics are key elements. However, current sensors and micro-electro-mechanical systems (MEMS) are usually fabricated on rigid substrates such as silicon wafers or chips. Hence, their application is limited to scenarios, which feature a rigid and flat substrate on that the sensor is mounted. In order to enable new sensing applications, e. g. on surfaces having a complex geometry or which are moving, flexible sensor concepts need to be developed. Beside flexibility and mechanical stability, additional requirements depend on the targeted application and can include thermal stability, chemical inertness, optical transparency or biocompatibility. Addressing mass markets, low-cost fabrication technologies are preferable. Parylene is a thermoplastic polymer which combines are variety of excellent properties, such as high flexibility, low Young's-modulus, no internal stresses, hydrophobicity, chemical inertness against all common acids, bases and solvents, optical transparency, dielectric properties, thermal stability, and a low permeability for moisture and gases. Additionally, some types of Parylene, such as Parylene C, are biostable and biocompatible according to ISO 10993. Due to its superior properties, Parylene is an excellent substrate material for the realization of flexible sensors and electronics.

Fabrication Technologies

Parylene itself can be patterned by different technologies, such as oxygen plasma and laser ablation. Due to its chemical inertness and thermal stability it is compatible with most of the available wafer based MEMS technologies. These include but are not limited to physical vapor deposition (PVD) metallization technologies, printing, lithography, wet etching, electrochemical deposition, and microfluidics.

Flexible Electronics

For the realization of metallic conductive paths and electrodes a variety of metals, such as Au, Ag, Cu, Al, Ti or Cr are available. These metal structures can be fabricated by sputtering with subsequent lithography and wet chemical etching, but also by lift-off processes and printing, which refers to different printing technologies such as Aerosol Jet printing, screen printing or inkjet printing.

Flexible pH Sensor

Based on Parylene substrate a flexible potentiometric pH sensor was developed, which consists of a two electrode setup (working electrode and reference electrode).
Doing so, a pH sensitive coating was electrochemically plated on patterned seed layers, made by PVD. This sensor shows a super-Nernstian pH sensitivity of about > 65 mV/pH (at room temperature) for a wide range pH range of 4 … 10.
Due to the implemented materials, the sensor is fully bio-compatible and features an excellent robustness i. e. against harsh chemical environments.

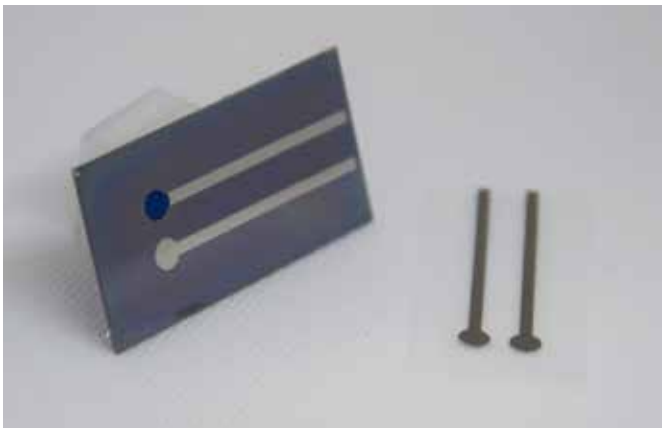
Flexible Gas Sensors

For the detection of water vapor but also volatile organic compounds, such as Propanol or Toluene, a flexible resistive gas sensor based on a Parylene substrate was developed. Doing so, metal electrodes were realized by PVD and subsequent patterning, followed by the deposition of a gas sensitive coating on basis of organically linked noble metal nano particle networks. The fabricated flexible gas sensors feature a high sensitivity of up to 100 ppm for the above-mentioned gases, short response times as well as an excellent stability against mechanical impacts, such as bending or twisting.

Suggested Applications

- Smart Systems
- Smart Cards
- Smart adhesive tapes
- Wearables
- Geometry adaptive sensing

Metal electrodes on a flexible Parylene substrate, coated with a gas sensitive layer for the realization of a flexible gas sensor.



Flexible pH sensor with working and reference electrode on Parylene substrate before and after lift-off from a carrier substrate.

In cooperation with

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