DESIGN AND FABRICATION OF A VOC SENSOR

Sabancı Üniversitesi FACULTY OF ENGINEERING AND NATURAL SCIENCES

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ABSTRACT

Chemical vapor deposition is a method used for creating thin films and augmenting substrate surfaces at nano scales which provides high quality materials at a good price-performance ratio. In this project, initiated chemical vapor deposition machine allows adjustable conformal polymer coating by controlling the concentrations of the initiator and monomers on the cantilever surface. Polymer coated side of the cantilever that will interact with the analyte, generally results in swelling of the side since generally the polymer is engineered to produce a large stress when it reacts with the target, pushing the gold side down and create short circuit. By this method, a chemical signal can be transformed into an electrical response with a chemiresistive polymer.

OBJECTIVES

First step to accomplish determined objectives were to learn how to use Initiated Chemical Vapor Deposition, it's techniques, and purposes of different types of polymers. After learning these, implying knowledge to main objectives which are to design and fabricate Volatile Organic Compounds Sensor and to improve already designed systems.

INITIATED CHEMICAL VAPOR DEPOSITION

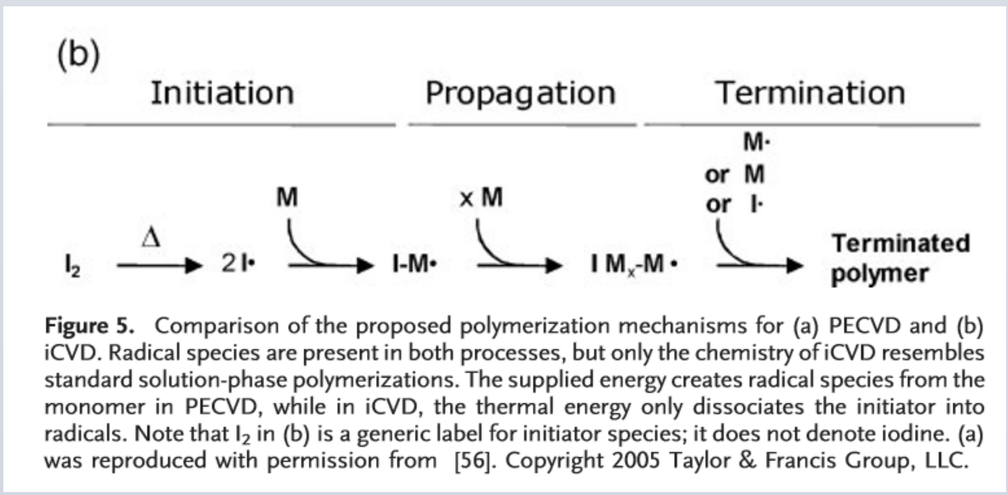
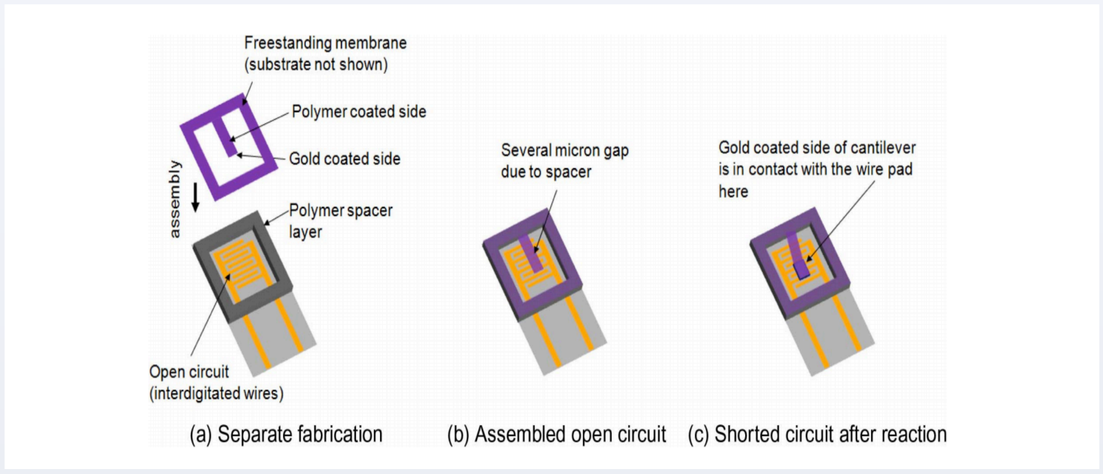


Figure 5. Comparison of the proposed polymerization mechanisms for (a) PECVD and (b) iCVD. Radical species are present in both processes, but only the chemistry of iCVD resembles standard solution-phase polymerizations. The supplied energy creates radical species from the monomer in PECVD, while in iCVD, the thermal energy only dissociates the initiator into radicals. Note that I_2 in (b) is a generic label for initiator species; it does not denote iodine. (a) was reproduced with permission from [56]. Copyright 2005 Taylor & Francis Group, LLC.

Chemical vapor deposition is a method used for creating thin films and augmenting substrate surfaces at nano scales which provides high quality materials at a good price-performance ratio. Adding free-radical initiator, Initiated Chemical Vapor Deposition, augments deposition rate, allows coating delicate substrates and decreases energy needed. In this project, iCVD machine allows adjustable conformal polymer coating by controlling the concentrations of the initiator and monomers on the cantilever surface. iCVD enables different types of polymer coating on the cantilever which has target specific functional group that provides chemical reaction with the target analyte. With this method, many classes of the compounds can be detected.

VOC SENSOR

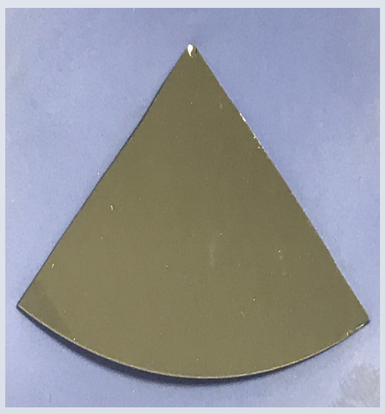


VOC sensors have consecutive cantilevers that one side is polymer coated, the other side is electric conducting material coated. Cantilevers made by etching the silicon nitride membranes through the borders with the CF_4. Then, sample is cleaned by oxygen plasma which also removes the photoresist of the cantilever. The front face which will make the short-circuit is coated with 3 nm electron-beam-evaporated titanium for adhesion promotion, and 5 nm gold for conducting electricity. In the next step, non-gold side of the cantilever is coated with a polymer in iCVD machine.

Polymer coated side of the cantilever that will interact with the analyte, generally results in swelling of the side since generally the polymer is engineered to produce a large stress when it reacts with the target, pushing the gold side down and create short circuit. Before the reaction, device is an open circuit, which displays insignificant power, after the reaction the resistance drops by over six orders of magnitude. Causing a conductivity change by swelling or reaction's act to dope a semiconducting polymer leads to yield a chemical response into an electrical response with a chemiresistive polymer.

Response time of the sensor decreases as the bending force and the deflection magnitude of the cantilever increases. As a result, there must be a good adhesion between the polymer and cantilever and polymer must develop huge stress by reacting with the analyte to have a low response time.

RESULTS



In this project five coatings have been done through one month period and different types of monomers were used for the depositions. One of those monomers is HEMA. HEMA is a hydrophobic monomer which provides hydrogel films and systematic tuning of surface energy and degree of swelling. EGDMA monomer is a cross linker which generally is used for making the other monomer, such as HEMA, more hydrophobic. Another monomer that was used is GMA. It is used for adhesion promotion that enables successful coating for further depositions.

CONCLUSION & FUTURE WORK

Initiated Chemical Vapor Deposition techniques and characteristics of different types of polymers are studied. Design and fabrication of Volatile Organic Compounds Sensor is learned.

Future work includes fabrication of already designed VOC sensors, determining it's deficiencies, and improving them by adding new features.

REFERENCES

Arora, W., Tenhaeff, W., Gleason, K., & Barbastathis, G. (2009). Integration of Reactive Polymeric Nanofilms Into a Low-Power Electromechanical Switch for Selective Chemical Sensing. Journal of Microelectromechanical Systems, 18(1), 97-102. doi:10.1109/jmems.2008.2008529

Tenhaeff, W. E., & Gleason, K. K. (2008). Initiated and Oxidative Chemical Vapor Deposition of Polymeric Thin Films: iCVD and oCVD. Advanced Functional Materials, 18(7), 979-992. doi:10.1002/adfm.200701479

Chemical vapor deposition. (2017, July 24). Retrieved August 13, 2017, from https://en.wikipedia.org/wiki/Chemical_vapor_deposition