An Environmentally Friendly Method of Sensor Production using Electron Beam Lithography

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The development of sustainable technologies that reduce waste, optimize the use of resources, emit the least amount of pollutants, and increase energy efficiency is a priority for societies seeking to minimize their environmental footprint. Electronic circuits are among the human made devices whose production entails large environmental impact in the disposal of production waste and in recycling methods. The increasing demand for more electronic devices highlights the necessity of new techniques to replace the current method of circuit fabrication. We studied a new approach for metallization of electronic circuits using an autocatalytic technology.

Auto-catalytic metallization uses the same chemical reaction as conventional electroplating technology, but it employs a self-sustaining reaction using a noble metal seed layer to start the process. The essential benefit is elimination of the requirement of having anode and cathode to drive metal deposition. Instead, the chemicals deposit in a manner similar to biological cell production, without requiring any external energy supply or source to carry on the reaction. This so-called electroless plating is already in use for the fabrication of circuits, especially for the plating of vias in printed circuit boards. The new feature of this study is the use of a seed layer which is can be patterned by using a very easy and affordable method. This process greatly reduces the complexity and number of steps required for fabricating devices, compared to typical methods employing both deposition processes such as sputtering/thermal evaporation and etching.

An electron microscope (SEM) was used to create the seed layer pattern, using electron beam lithography. This method allows the creation of very precise and accurate micro and nano sized patterns smaller than those produced by the use of traditional UV light. The first step in our study was to determine the correct energy and dosing of electron beams to produce sharp patterns, that are neither underexposed for incomplete patterns, nor overexposed so as to incur pattern bleeding. The desired exposure for the SEM used ranged from 100-150 micro-Coulombs per square centimeter. Visual inspection under a light microscope was used to find the desired dosage.

A line test was used to determine the smallness of feature sizes that can be produced with this process. This consisted of lines ranging from 20 micrometers to 100 nanometers inside of a box for ease of location and visibility. The lines disappear at the visible limits of light microscope as expected, with the smallest visible line being at one micrometer. The electron microscope is used to assess the existence and accuracy of patterns smaller than this. The samples were produced on nonconductive photo-paper and FR4.

Creation of PM2.5 sensors and gas sensors is the current goal of this project. A PM2.5 sensor is capable of measuring and the amount of particulate matter 2.5 micrometers in size or smaller suspended in a gas, using infrared radiation scattered in the gas and measuring the intensity with microsize patterns. Producing a PM2.5 sensor using SEM lithography would introduce to the market a high performance sensor at potentially lower cost than previously developed in a much smaller in design.

This method of fabrication using SEM lithography to create a seed layer for electroless plating has the potential to greatly impact the micro and nano sensor industry. Creating precise circuitry efficiently and in an environmentally safe method is the desired impact of this research. This work demonstrates the plausibility of the method.