INTEGRATED CHEMICAL SENSORS FOR ENVIRONMENTAL POLLUTION

MATNANTECH Project no. 24 (2001-2004)

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1. RESEARCH OBJECTIVES

The project is devoted to the design of chemical sensors based on both polymeric and semiconductor oxide film, deposited on silicon substrate. The best sensitivity relative to specific molecular species as CO, NH_3, NOx, CH_4, has been investigated to found the most adequate application. The main objectives are to determine the appropriate solutions for the device layout and to relate the processing of the sensitive layer to the planar integrated technology .

2. RESULTS

The main innovation is related to layout and tehnology design. Also the project focuses the research on the nature of an appropriate sensitive layer deposited on SiO_2 / Si substrate. The film structure induced by deposition conditions and annealing is correlated to electrical response. The research based on both spectrometric techniques and advanced calculation method is expected to give solutions for technological applications related to the fabrication of Integrated chemical sensors .

The main results already reported are related to the characterization of both polymeric and oxide films used as chemical sensitive layers, by means of optical spectrometry.

The investigations were carried out for the characterization of polymer films deposited in a plasma reactor starting with the monomer species. The calculated IR active frequencies and the corresponding transition probabilities were done for an assumed polypirol model structure being compared with IR data of the thin polymer layer deposited in plasma.

The plasma deposited polymer structure is similar to the films obtained by usual chemical methods. It was confirmed by the fact that almost all absorption bands of the simulated spectra, agree with those of the plasma deposited films. Fig.1 indicates that the molecular structure is representative for the deposited film on Si/SiO_2 structure.

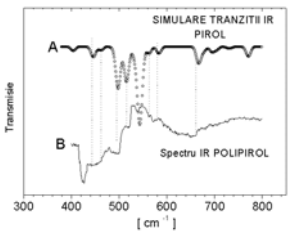
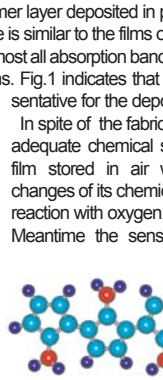


Fig. 1

In spite of the fabrication of an uniform layer, with an adequate chemical structure, the stability of the thin film stored in air was found unacceptable. The changes of its chemical structure is determined by the reaction with oxygen.

Meantime the sensitivity of the plasma deposited polymers as polypirol, anylyne and anysidine was found to be decreased by aging degradation after an air storage of about few days. The low chemical stability is determined by the dangling bonds generation during film deposition. It suggests further investigations to solve the problem by post growth annealing. The complementary research theme was related to the investigation of the semiconductor oxide. The best candidates was considered WO_3, wich is a high sensitivity, low hysterezis and a fast response to NH_3 material. Fig. 2 shows the main absorption bands of a typically WOx film obtained as a result of a high temperature evaporation technology. WOx related vibration modes are indicated at 750, 1376,and 1470 cm-1.



The sensor structure is based on a Si/SiO_2/ Al / WOx structure. The electrical signal determined by an air flux which contains ambient water vapors is indicated Fig.3. The fast decreasing electrical resistance with a time constant of 1.5sec is followed by a recovery process of about 10sec. after the air flux is stopped. The presence of NH_3 molecules in air flux determined a different response. The device impedance increases above its previous value after switching off the gas flux. The standby state recovery time is about 25 seconds, (upper curve in Fig3). The reversibility to On-Off air -H_2O flow cycles was found very satisfactory as it is shown in fig. 4.

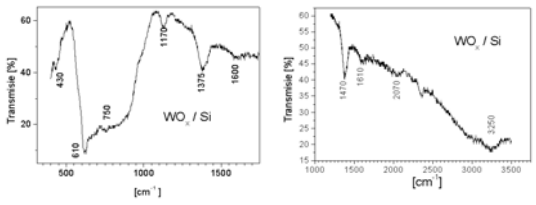


Fig. 2

The flux of air and moisture is set up and down for four times. The fast sensor responses are proportional with the water molecule amount carried by the air flux as it can be deduced from the volume of gas which flows upon the sensor. The signal decreases by 50% as a result of the air flux reduction with the same percentage. The estimation for the results expected in 2003, are related to the final solution for sensor layout, technology and electrical response to molecular species such as NH_3, CO, H_2O , CH_4

3. PARTNERSHIP

- National Institute for R&D in Microtechnologies,
- National Research Geology Institute,
- Petru Poni Research Institute,
- National Institute for Materials (IFTM).

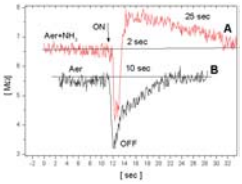


Fig. 3

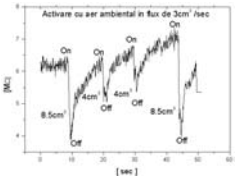


Fig. 4

OPTICAL RECONFIGURABLE NEURON - RESEARCH, DEMONSTRATOR EXPERIMENTATION AND PARAMETERS EVALUATION

MATNANTECH Project no. 20 (2001-2004)

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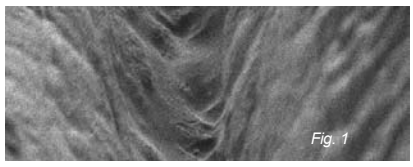
The aim of the project is to realize and characterize a demonstrator of an optical reconfigurable neuron, so as be able to conceive devices that process information in many fields of activity where a non-binary approach is more well-suited for solving the problems. The team is a multidisciplinary research group of specialists from the National Institute for Research and Development in Microtechnology from Bucharest, as well as from the Faculty of Physics of the Bucharest University. Other specialists from ROMES S.A. are contributing with their experience, also. The device structure, containing some unusual materials for microprocessing such as are Potassium Dihydrogen Phosphate (KDP) crystal and chalcogenide glasses. These kinds of materials neccessitate a special way of processing in order to realize the structure. The project is under run and a number of interesting preliminary results have been obtained. These results refer to the possibility to microprocess the respective materials, so as the final optical neuron structure be miniaturized at dimensions of 100 mm x 100 mm. Below we present the SEM image of a laser surface engraved KDP crystal (figure 1) and the AFM image of the surface of the chalcogenic thin films deposited onto an Al surface (figure 2). The depth of the channel in figure 1 is 400 mm. The smoothness of the chalcogenide thin film suggests the possibility to use this kind of material for microprocessing purposes. The ability to microprocess the KDP crystal opens up the possibility to realize MOEMS that contain integrated KDP crystals. All these preliminary results represent also start points for other research directions in the field of microsystems technology.



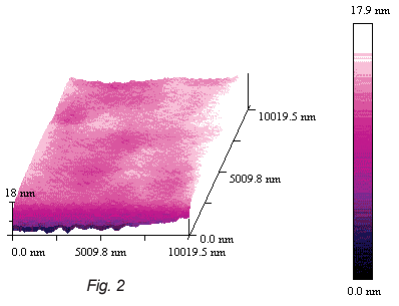


Fig. 2

SELECTIVE ACCELERATION OF POWER SEMICONDUCTOR AGING BY LASER IRRADIATION

MATNANTECH Project no. 6 (2001-2004)

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1. RESEARCH OBJECTIVES

- to obtain the optical acceleration of the minority carriers generation-recombination at deep level trapping centers of semiconductor devices;
- to achieve the experimental model and the prototype of the equipment for accelerate the generation-recombination processes in the deep level trapping centers;
- to elaborate the technology for selective acceleration of power semiconductor devices aging;
- to introduce the selective acceleration of aging by laser irradiation, in the manufacturing process of power semiconductor devices.

2. INNOVATION & EFFECTS

This project introduces a new technological process for reliability screening.

The first idea is to carry out the reliability screening process on semiconductor chips. Important materials, manual labor and energy savings are obtained, because the accelerated aging process is not performed at the end of the manufacturing process..

The second idea is to use an optical acceleration of minority carriers generation-recombination, instead of the thermal acceleration. The optical acceleration needs low energy consumption and can be applied on semiconductor chips. Using the adequate wavelength of laser radiation, one can achieve a selective acceleration of aging, which acts only in the deep level trapping centers. Thus, the acceleration factors can be orders of magnitude higher and important decrease of aging duration is obtained.

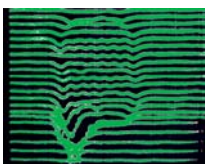

Figure 1. Laser scanning analyse on a 2N 3375 transistor chip. The local increasing of the photo-induced current, at a deep level center area

3. RESULTS

- the experimental model of the technological equipment for accelerate the minority carriers generation-recombination processes in the deep level trapping centers, was achieved;
- the optical acceleration of the minority carriers generation-recombination in deep level centers, was emphasized (Figure 1).