MILLIMETER WAVE RECEIVING MICROSYSTEMS MANUFACTURED BY SILICON MICROMACHINING

MATNANTECH Project no. 86 (2002-2004)

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The aim of the project consists in design, manufacturing and characterization of a new micromachined filters antennae and hybrid integrated receivers' family, with working frequency in 35 GHz and 45 GHz range. This microsystem family for millimeter wave will be processed by silicon micromachining. The principal objectives of the project are:

· Modeling, manufacturing and experimental characterization of antennas supported on micromachined $SiO_2/Si_3N_4/SiO_2$ membrane;

Modeling, manufacturing and experimental characterization of high performance band pass filters based on silicon micromachining;

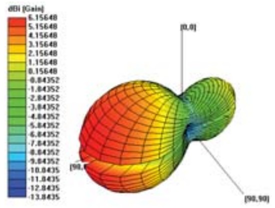
· Design, manufacturing and experimental characterization of micromachined receiving microsystems;

· Technical documentation and technical-economical documentation.

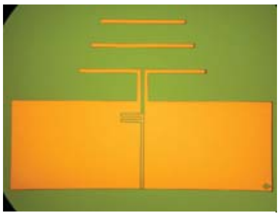
PARTNERSHIP

· FORTH-IESL Heraklion, Greece; ITC IRST Trento, Italy; Military technical Academy, Bucharest; "Valahia" University, Targoviste; S.C. ROMES S.A.

Result obtained up to now:



45 GHz Yagi antenna - 3D radiation pattern



35 GHz micromachined Yagi antenna structure

(a) (b)
35 GHz band pass filter structure supported on a thin $SiO_2/Si_3N_4/SiO_2$ membrane:
(a) top view; (b) bottom view - with top illumination

MICROMACHINED SENSING STRUCTURE FOR NUCLEAR RADIATION DETECTION

MATNANTECH Project no. 75 (2001-2004)

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The aim of this project was to develop one new type of sensing structure for nuclear radiation based on new principle - tunneling effect. For this purpose, new semiconductor micromachining and packaging techniques were developed, in order to obtain metalised nanotypes. Results obtained in this project show that it is possible to obtain new sensing structure based on tunnelling effect.

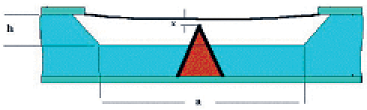

Fig.1. Cell configuration: a=500μ =0,5mm; h=7μm=0,007mm; x=distance between tip and membrane; chamber vol. =(500)2·7μm3=1,75 10-12m3

a) SENSING STRUCTURES MODELING

The nuclear radiation detector structure used for modeling is presented in Figure 1. Modeling shows that this structure can be used for medium and high magnitude nuclear radiation sources.

b) SIMULATION OF THE SENSING STRUCTURES

The purpose of simulation in this paper is to obtain a maximum deformation of the membrane, which means in this case a bigger detected magnitude of the current, so a better sensitivity of the structure. The simulated sensing structure is presented in Fig. 2.

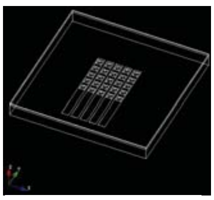

Fig. 2. The simulated area of the sensing structure

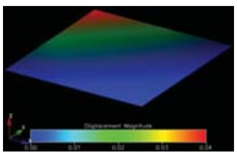

Fig. 3. The mechanical analysis of the membrane using a neutron source with mCi intensity

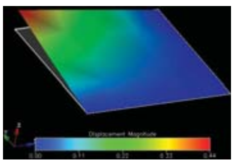

Fig. 4. The mechanical analysis of the membrane using a neutron source with hundred of mCi intensity.

For this configuration, the mechanical simulation of the membrane, using COVENTOR software (Fig. 3). The maximum deformation of the membrane is 44.5 nm. When a source with a higher intensity is used, the mechanical analysis of the membrane shows a 10 times bigger deformation (Fig. 4). Mechanical analysis for a 0.1μm Al layer is presented in Fig. 5 and shows a 71.1 nm membrane deformation. In Figure 6 is presented

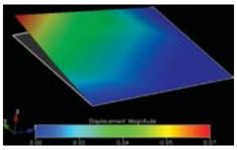

Fig. 5. The mechanical analysis of the membrane covered by a 0.1μm Al layer.

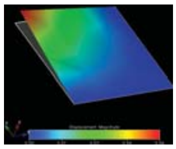

Fig. 6. The mechanical analysis of the membrane using a neutron source with mCi intensity: for 1μm membrane thickness

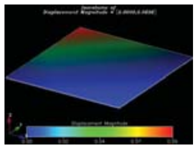

Fig. 7. Influence of the voltage between membrane and tips on membrane deformation

the mechanical analysis for a 1μm membrane thickness, which show that the deformation increases with 25%. Last simulation presents the membrane deformation for a voltage applied between membrane and tips (100V) - the membrane deformation in this simulation was 90 nm (Fig. 7).

c) EXPERIMENTAL RESULTS AND MEASUREMENTS

During this step, masks for sensing structure were design and manufactured.

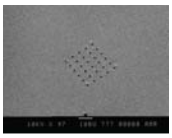

Fig. 8. SEM photo of the metalised nanotype array

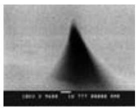

Fig. 9. Detail view of one metalised type - SEM photo.

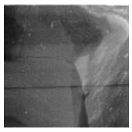

Fig. 10. SEM photo of the polyimide membrane (detail).

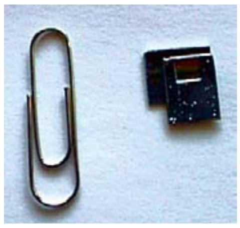

Fig. 11. Top view of the sensing structure

The sensing structure is composed by two different components, a metalised nanotype array and a metalised polyimide membrane, manufactured on different wafers. Both components were obtained by wet chemical etching of the wafers using $H_3PO_4/CH_3OH/H_2O_2$ (1:1:3) or $H_2SO_4/H_2O_2/H_2O$ (3:1:1) solutions. Results are presented in Figures 8-10. These two components were assembly in order to obtain the sensing structure. Top view of the sensing structure is presented in figure 11.

Measurements were performed using a γ radiation source (2mCi intensity). The current intensity increases with the voltage applied between membrane and tips Although this structure was designed for α and ß radiation, an significant increasing of the signal can be observed for γ radiation.

New trend in this field is to develop radiation detectors manufactured on semiconductor compounds.

For the first time sensing structure for nuclear radiation based on tunneling effect were designed and manufactured. These structures can assure superior performances against the present detectors. Sensing structure based on tunnelling effect have some advantages like: miniaturization, which permits punctual measurements; chip detector structure; real time acquisition data.