THE CALCULATION OF PERFORMANCE INDICATORS USING HIGH-TECH TECHNOLOGIES FOR MEMS & NEMS FROM THE INDUSTRY OF MICROELECTRONICS

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Abstract - The high-tech industries are characterized by the obtaining of temporary monopoly rents caused by the barriers to market entry of these products of competitors; generating a cumulative process of the specialization. The achievements in the field of nanoscience and nanotechnology have a major impact. The benefits of these new technologies are including materials and manufacturing processes, electronics, computers, telecommunications and information technology, medicine and health, environment and energy storage technologies and biological agriculture. The subject covered by this article is the monitoring of each stage of the technological process of manufacturing microelectronic circuits, in particular by SEM and AFM microscopy because the problems that arise in these flows nanotechnology depends on the quality and the processing of surfaces.

Keywords: nanotechnology, technological flow, MEMS, NEMS.

1. Introduction

The commercial interest for the applications in the high frequency spectrum has undergone significant growth in recent years. For technical applications that are using high frequencies of tens and hundreds of GHz, achieving the electronic circuits require the use of some kind of technologies for obtaining them at micro- and nano-scale.

MEMS and NEMS devices provide opportunities interface (sensor-transducer) between electronic circuits and the environment. The first applications of MEMS systems / NEMS were in the automotive industry in order to increase safety. MEMS circuits have millimeters in size or micrometer and NEMS circuits have submicrometer sizes. Thus, in the process of obtaining these circuits, are necessary to be used advanced technology with high precision to achieve MEMS structures / NEMS.

1.1 Presentation of the processes used in the manufacturing of micromachined circuits for the millimeter and waves centimeters waves

The communications systems of the new millennium, through the huge increase of the number of users, by saturating the existing frequency bands, involves the realization of high performance components into the frequency spectrum from the field of the millimeter and millimeter wave.

Is therefore necessary to obtain MEMS systems (MicroElectroMechanicalSystems) and systems made by micromachining with applications in radio frequency. The novelty of the micromachining technologies consists in removing on a selective way the substrate of the semiconductor obtaining circuits, basically "suspended in air", thereby avoiding the losses.

Obtaining the three-dimensional mechanical structures is possible by combining and modifying various technological methods used in microelectronics (filing, etching, ion bombardment, photolithography, etc.). The materials used are based on silicon, gallium, polymers and metals. The fact that the process MEMS is an extension of traditional methods is crucially important, because in this way it is compatible with VLSI technologies (very large scale integration) CMOS, are allowing the achievement on the same chip both the the mechanical part, as well as the electronics. The design of the mechanical parts of the chip must take into account the effects that can occur in the case of so small dimensions, as now will become obvious the electrostatic forces and the surface tension effects.

1.2 MEMS technical analysis through the AFM technique

The Atomic Force Microscope AFM (Atomic Force Microscopy) belongs to the family of scanning sensor microscopes or SPM (scanning sensor
Microscope) which sweeps an sharp sensor over a sample to follow the interactions between the sensor and the sample. Thus is determined the local key performance indicators, such as:

- height
- magnetic properties,
- optical absorption,
- etc ...

1.3 SEM technique represented through the Electronic Microscopy

Is one of the the most modern techniques through which can be obtain detailed information about the following performance indicators:

- structure
- surface morphology of the materials.
- etc.

Morphological and surface analysis of materials is very important for further study and understanding of the physico-chemical properties. The Scanning Electron Microscope (SEM) uses the electrons beam incident focused on the sample in a point whose x and y coordinate varies over time so that the sample is regularly explored (swept).

STM technique is used only for conducting or semiconducting surfaces. Insulating surface topography can be highlighted only if they are covered with a thin layer of conductive material who create conditions for the emergence of a tunneling current. The microscope can be used both in the vacuum as well as in a normal atmosphere.

1.4 Description of the nano technology for manufacturing semiconductor devices

The basic processes used in the manufacture of semiconductor devices are:

- Increased wafer which ensure the preparation of monocristalline substrate;
- Fotolithography which ensure the definition of regions (by masking) on the wafers through the selective processing;
- The doping represents the addition of impurity that are desired on the wafer surface in order to achieve specific surface substrates doped n or p-type impurities in certain concentrations;
- The oxidation consists of increasing the thermal insulation of a dielectric layer (e.g.. SiO2), which is the key element who performs insulation between the semiconductor and the conductive layers. Silicon is a very important element for the microelectronics integrated because is a good natural oxide.

2. Application: comparative study performed through the SEM and AFM microscopy on representative surfaces of silicon wafers, in the MEMS and NEMS Mechatronics Laborator from INCDMTM

As an example of concomitant use of two microscopy techniques, in this case AFM and SEM, for the control of surface quality of some silicon wafers used in making MEMS, were achieved images to determine the properties: surface roughness and topography view.

![SEM images of surfaces](image1)

**Observations**

An representative area of a unpolished Si wafers (300 x 180 μm), the average of the roughness: Sm = 32 nm

An representative area of a unpolished Si wafers (300 x 180 μm), the average the roughness: Sm = 0.08 nm

An representative area of a unpolished Si wafers (900 x 700 μm), the average the roughness: Sm = 14 nm

An representative area of a unpolished Si wafers (1000 x 700 μm), the average the roughness: Sm = 8 nm
3. Conclusions

The presentation highlights the area of nanotechnology as an important direction for the development of science worldwide, given its application areas. Innovation among the materials, systems and nano techniques are opening up new opportunities for the development of improved nanosystems and nanomaterials. Their use in various industrial applications requires prior processing in order to obtain improved results.

For technical applications that use high frequency the realization of electronic circuits requires the use of technology to obtain these of micro and nano dimensional scale.

Obtaining three-dimensional mechanical structures is possible by combining and modifying various technological methods used in microelectronics (filing, etching, ion bombardment, photolithography, etc.). MEMS devices are manufactured by using the technique of integrated circuits combined with microprocessing of the specific surface.

Electronic microscopy is one of the most modern techniques with which you can obtain detailed information about the MEMS structure. In the automotive industry, MEMS are largely used to control and monitor the functionality of various electronic subsystems for passenger comfort and safety.

Other methods or calibration systems that can be used to calibrate the serial production are:

- inertial devices that allow obtaining of an sudden variations of the movement on 3D coordinate axes;
- use the simulation programs for inertial mass displacement from the MEMS accelerometer component.

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