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TECHNOLOGIES OF ELECTROCHEMICAL DEPOSITION OF METALS ON A SEMICONDUCTOR WAFER OF VARIOUS MEMS MICROFORMS

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The technology of formation of nanostructured materials with high physical and mechanical properties is considered. It allows significantly improve the quality and reliability of the moving elements of systems. The results of the choice of the optimal bath for electrochemical deposition of copper and cobalt-phosphorus alloy to obtain metal structures on a substrate of high quality and strength are presented. For the formation of components of complex microsystems, filling by the method of galvanic codeposition is proposed. The technology of deposition of coatings from metals, alloys, as well as composite coatings on a surface with a complex nanometer configuration has been developed. Samples were obtained and showed absence of typical defects such as voids, seams, as well as increased coarse grained structure.

Key words: microelectromechanical system; electrochemical deposition; LIGA-like technology; carbon nanotube; galvanic deposition.

INTRODUCTION

At a high rate of development in the creation of modern microelectronics and optoelectronics, elements and systems are in demand, which are increasingly small and complex in configuration. These include: micro-optical components (microlens array), microelectromechanical systems (microcompressors, accelerometers, microactivation devices), microchannels, microsystem connecting elements and others, for which a structure is obtained in geometry that changes in three directions. Their formation is a combination of various technical approaches based on the design and creation of polymerization microforms, the minimum dimensions of the elements used, on the basis of the creation of polymer microforms and their subsequent filling with functional materials.

Formation of micro- and nano-level functional structures, thanks to the technology of creating microelectromechanical systems (MEMS) [1]. MEMS is manufactured in solid quantities with a limited number of micromechanical components and equipment that links the integrated technology with microelectronics either independently or on its surface in the form of a complex microsystem less than a millimeter in size. It should be kept in mind that the reason for the emergence of the following technologies lies in the MEMS technology: LIGA (X-ray lithography on synchrotron radiation (LI), electroforming (G, Galvanoformung), and molding (A, Abformung)) [2], LIGA-like, including galvanic deposition, which make it possible to obtain it by systems of almost any complexity.

At the same time, with the transition to smaller overall dimensions of MEMS, it is important to ensure technological standards and requirements for the size and number of permissible defects of the mask (microform) used. This applies not only to defects in projection masks that arise during their manufacture, but also during their operation.

MATERIALS AND METHODS

When forming vertical contacts by the LIGA-like technology, the sequence of technological operations was determined in [3]. Electrochemical filling of micromolds is a key step in the creation of micro-parts.

The process of galvanic deposition (electrodeposition) of metals is carried out in special electrolyzers (baths) filled with electrolyte. Metal electrodes are immersed in the electrolyte, to which current is supplied from an external DC source. Under the action of an electric current, active penetration of metal particles contained in the electrolyte into the upper layers of the product or substrate begins. The properties of the deposited films depend on the electrolyte composition, current density, temperature, electrolyte stirring intensity, drift rate of metal ions, and the shape and state of the substrate surface. As a rule, rather thick layers of several microns are formed by electroplating. In the manufacture of microelectronic devices, a thin sublayer of metal is often sputtered by magnetron sputtering to improve adhesion before galvanic deposition.

Electrochemical deposition of metal was carried out from an electrolyte, the optimal concentration of sulfuric acid contained, provided high conductivity required to maintain an increased current density and reduce the active concentration of metal ions to obtain a large crystalline coating. The optimal composition of the electrolyte was chosen, which ensures high quality of copper deposition by a microform of large thickness (Fig. 1).

RESULTS AND DISCUSSION

As a result of this work, technologies for electrochemical filling of complex microreliefs with metals and alloys were developed. Copper plates, copper-coated fiberglass plates, sitall substrates with a sprayed copper layer, and semiconductor plates were used as substrates. The developed technology of selective electrochemical deposition of microform copper is intended for use in microelectronics in accordance with the latest world standards. In particular, it can be used to form vertical contact sequences of carbon nanotubes for performing DC magnetic studies.

The electrochemical deposition of copper was carried out from an electrolyte of the following composition: copper sulfate – 180 g/l; sulfuric acid – 40 g/l; hydrochloric acid – 0.02 g/l; thiourea – 0.05 g/l. The deposition was carried out with constant weak stirring, the current density was $j = 70\ A/m^2$, the duration of the deposition process was 30 min.

Electrochemical deposition of a cobalt-phosphorus alloy was carried out from an electrolyte of the following composition: heptahydrate cobalt sulfate – 280 g/l; cobalt chloride hexahydrate – 10 g/l; sodium hypophosphite – 20 g/l; boric acid – 30 g/l. The deposition was carried out with constant weak stirring, the current density was j = 25 A/m^2, the duration of the deposition process was 35 min.

As a result, samples of microstructures filled with various metals and alloys were obtained by the method of galvanic deposition. The quality of the obtained samples was assessed by scanning electron microscopy (Fig. 2). The obtained coatings did not contain such typical defects as seams, joints, increased grains and voids.

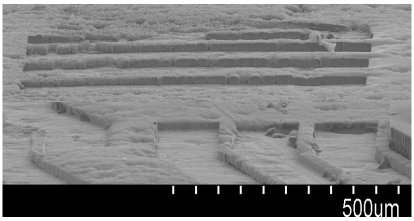

Figure 1. – SEM (scanning electron microscopy) photograph of the initial stage of a copper coating obtained by selective electrochemical deposition from sulfuric acid electrolyt

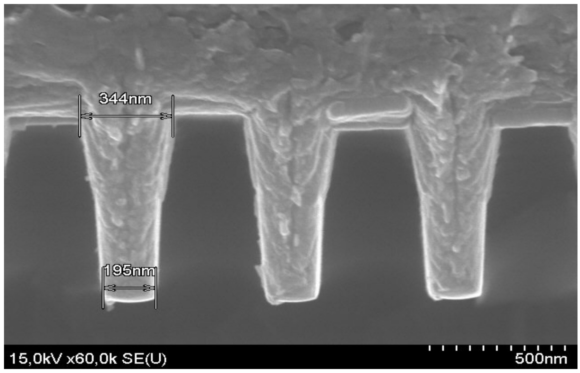

Figure 2. – SEM photograph of a cross-section of a semiconductor wafer with a deposited nickel-based material

CONCLUSION

Thus, the high quality of the obtained coatings makes it possible to use this technology of electrochemical filling in the creation of interconnections of such complex systems as solid oxide fuel cells (SOFC), IC with an ultra-high degree of integration (ULSI), etc., as well as for filling micro and nanogrooves, both dielectric and metal gratings in the composition of polarizers.

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