Raman scattering spectra of $FeIn_2S_4$ single crystals are presented in Figure 2.

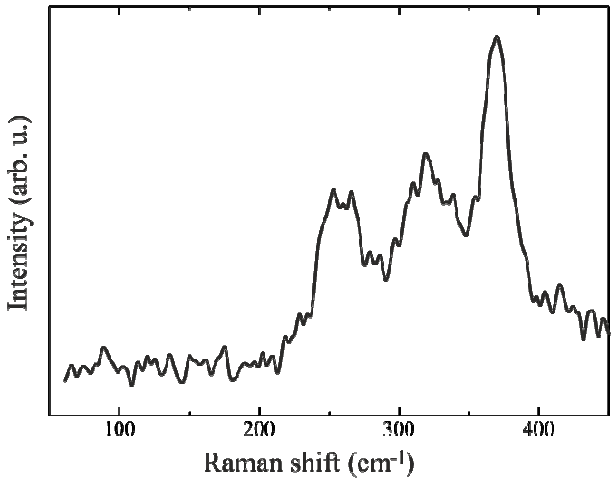

Figure 2 – Raman spectra of FeIn2S4

Raman spectra (Figure 2) in inverse spinels have complex behavior. The bands are broadened and partly more than five Raman bands (as predicted by group theory) are observed, with up to three $A1_g$ species instead of one. These findings probably arise from the lack of full translation symmetry in inverse spinels due to the random distribution of the bivalent metals and indium on the octahedral sites. The observed additional bands were assigned to $F1_u$ longitudinal phonon modes, which have been claimed to be enhanced by resonance effects. However, as an alternative explanation it must be borne in mind that the additional bands are defect-induced modes also due to the breakdown of the translation symmetry.

III. CONCLUSIONS

The Raman and IR spectra for $FeIn_2S_4$, have been obtained by means of the microprobe technique. This technique is very useful in the present case because large single crystals of these compound, as required for conventional Raman measurements, are not usually available. The analysis of the results allows us to clarify the controversy in reported data on spinel $FeIn_2S_4$.

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MECHANICAL PROPERTIES OF MEMS COMPONENTS BASED ON ANODIC ALUMINUM OXIDE

S. Biran, D. Korotkevich, A. Korotkevich
Belarusian State University of Informatics and Radioelectronics, Minsk, Belarus

I. INTRODUCTION

Devices based on microelectromechanical systems (MEMS) are widely used in industrial electronics, medicine, military and space hardware. MEMS combine both electric and mechanical components. Their functional characteristics are defined by mechanical properties of material, they are based on.

Nowadays, silicon and its modifications are the most used materials in MEMS technology, because of its good physical and mechanical properties. MEMS technology based on silicon doesn't always allow to

create necessary geometry of element. This technology is connected with high-temperature process (500-1200ºC), which decreases physical and mechanical properties and causes high mechanical stresses.

According to this, wide and intensive research in the field of using new materials such as polyamide, permalloy, ceramic-polymer composite materials, etc. is being made. One of the most perspective material among them is anodic aluminum oxide (AAO), which, possesses good physical and mechanical properties which can be varied in the wide range by changing of regimes of anodizing. The anisotropy of etching of AAO films allows to form volume MEMS elements with high aspect ratio [1]. Besides, the formation of MEMS is well compatible with the thin film technology. Sensors with a sensitivity element in form of a membrane can be formed by using anodic aluminum oxide [2].

II. SENSOR WITH AN ACTIVE ELEMENT BASED ON AN AAO FILM

Sensor presented on Figure 1 consists of anodic alumina membrane with moving plate of capacitor, formed on it. Membrane is fabricated in aluminum frame, which provides hardness and mechanical strength. Metal or dielectric substrate can be used as a base for placing anodic alumina membrane. This base has second capacitor plate and measuring circuit, previously formed on it by photolithography.

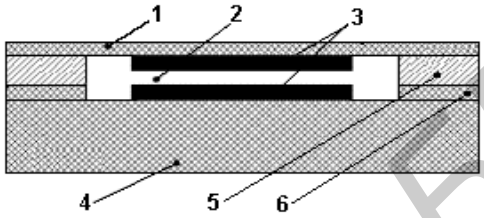

Figure 1 – Construction of sensor: 1 – membrane of anodic alumina,
2 – air gap, 3 – metal contacts, 4 –base, 5 – aluminum, 6 – anodic alumina

0.9 mm thick aluminum was used as a material for membrane fabrication. Substrate preparation included cutting on the plates and thermostatic straightening. Substrates were etched in 10 wt. % aqueous solution NaOH to improve surface quality and to thin them. Precision surface treatment was performed by diamond turning process (Figure 2a). The masking before anodizing was performed with positive photoresist (Figure 2b).

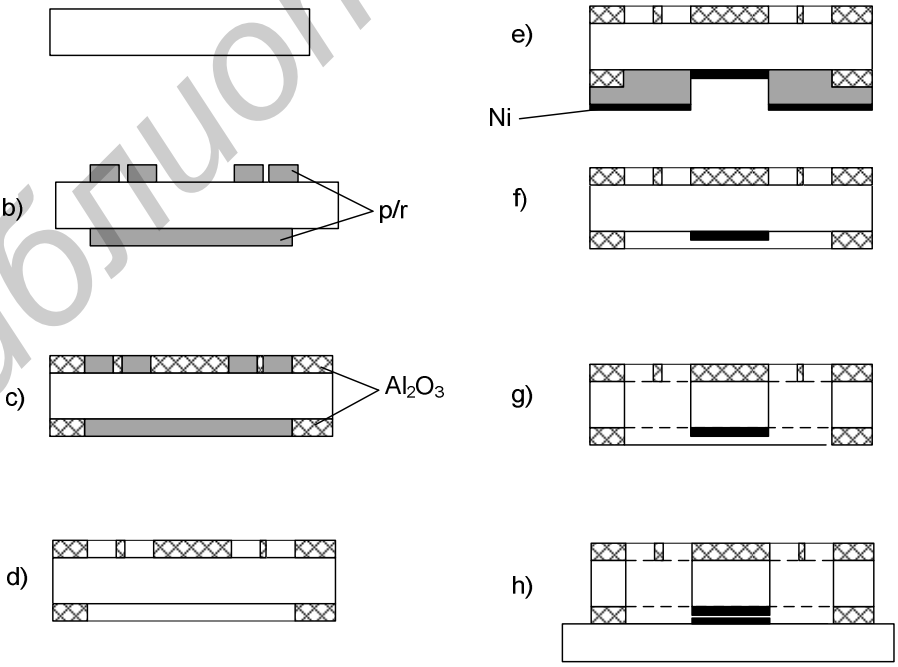

Figure 2 – Formation process of sensor

Double-sided anodizing was carried out in oxalic acid solution in the galvanostatic mode at current density about 25 mA/cm^2 during 4 hours (Figure 2c). Then photoresist mask was removed in

dimethylformamide and monoethanolamine solution (Figure 2d). The masking before deposition was performed with positive photoresist (Figure 2e). Nickel metal films were obtained by electron-beam evaporation in the Oratoriya-9 vacuum unit. After deposition, part of nickel film was removed using lift-off process (Figure 2f). Remaining part of Ni film will be used as top plate of capacitor. Etching of thick aluminum layer was carried out in hydrochloric acid and hydrogen peroxide solution (Figure 2g). The final move is to place obtained membrane on base (Figure 2h).

III. EXPERIMENTAL DATA

In the present work, research on influence of anodizing regimes and constructive parameters on sensitivity of anodic alumina membrane elements were carried out. Process of obtaining samples for measuring is similar to process of membrane fabrication described earlier. Oxide thickness of cantilever beam in this samples varied from 80 μm to 100 μm. Constructively they had different number of cantilever beams, as shown on Figure 3.

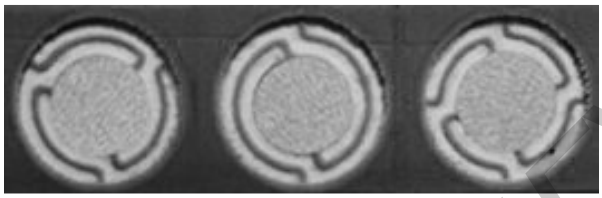

Figure 3 – Construction of membranes

Deflection value of samples with the applied mechanical load was measured using microinterferometer. Maximum value of mechanical load was under 20 mN. Sensitivity of samples was determined as ratio of deflection value to mechanical load.

We have obtained, that sensitivity value linearly depends on the mechanical load. Sensitivity value decreases with increasing number of cantilever beams.

In structure with 2 cantilever beams and 90 μm oxide thickness sensitivity value reached 58.5 μm/mN, with 3 cantilever beams – 14 μm/mN, with 4 cantilever beams – 5.5 μm/mN. In structure with 3 cantilever beams and 80 μm oxide thickness sensitivity value reached 19.5 μm/mN, with oxide thickness 90 μm – 14 μm/mN, with oxide thickness 100 μm – 9 μm/mN.

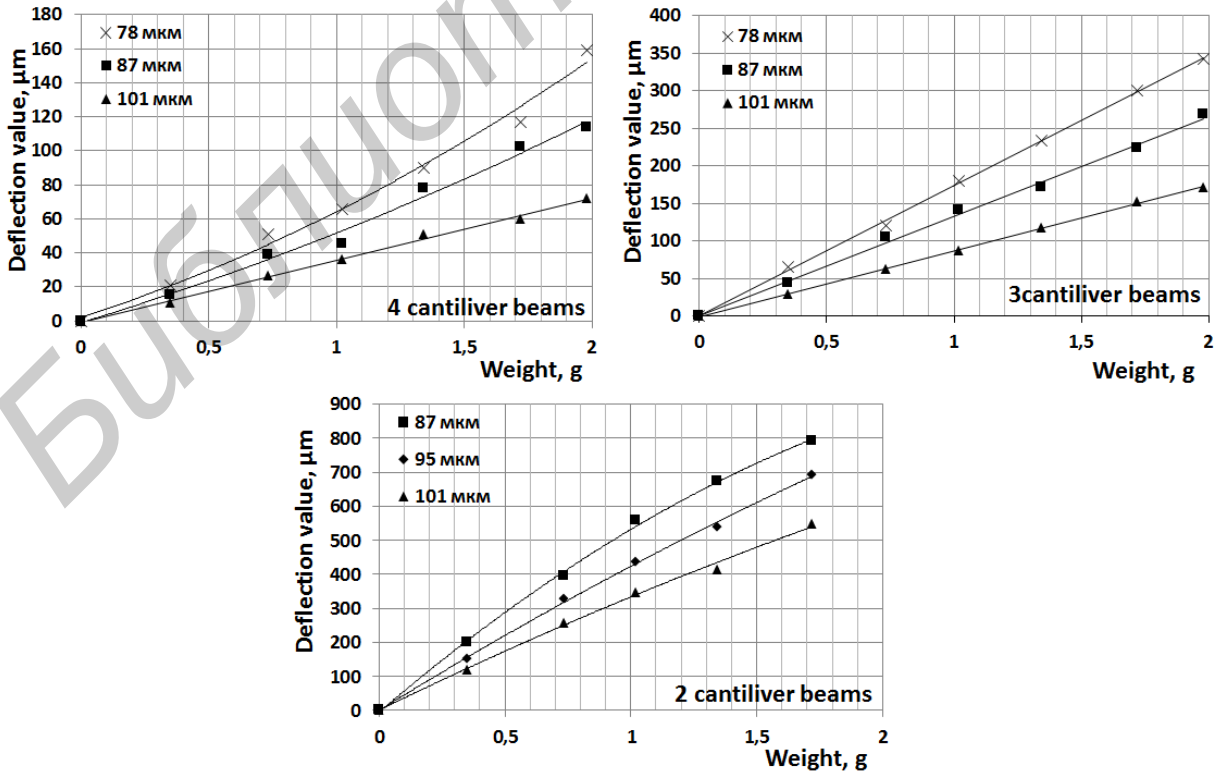

Figure 4 – Deflection value vs. weight for structures with different number of consoles

III. CONCLUSIONS

Fabrication process of sensor based on anodic alumina has been developed. It has been found that increasing number of cantilever beams and oxide thickness decreases sensitivity value. Adding one additional console reduces sensitivity by 75%, and two – by 90%. Increasing the thickness of the anodic oxide film by 10 μm, reduces the sensitivity by 30%. By varying the parameters of the anodizing can change the sensitivity range of the active element sensors in a wide range of values.

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THE REDUCTION OF GRAPHENE FROM GRAPHENE OXIDE

V. Labunov, L. Tabulina, L. Mikhnavets, A. Tkach
Belarusian State University of Informatics and RadioElectronics, Minsk, Belarus

I. INTRODUCTION

Graphene has a surprising combination of properties: transparency, mechanical strength, elasticity, peak mobility of charge carriers (Dirac massless fermions), and high thermal conductivity; it is elastic and impermeable with respect to molecules of the other substances. It is also more inert than gold when it comes to the effects of external conditions [1, 2].

All of these characteristics, which are apparent in different physicochemical processes, make graphene a highly promising material for practical use in everything from nanoelectronics to composite materials [3].

The best way of obtaining graphene today is to use graphene oxide produced in the form of flakes by laminating graphite with oxidizing reagents. This material can be considered graphite intercalated with oxygen-containing carbon groups that give it the ability to be thoroughly dispersed in water and hydrophilic organic solvents. When interacting with chemical reducing reagents, graphene oxide is converted into thin graphene flakes of low structural quality [4–7] due to the substantial degradation of graphite during the synthesis of graphene oxide. We nevertheless can obtain graphene from this material [6–10]. These data are, however, difficult to compare, since reagents that differed in their chemical properties were used, and the processes involving them were performed under different thermal conditions. In addition, graphite materials of different structural quality and fineness were used to obtain graphene oxide [7, 10].

In this work, we therefore study the effects the reducing agents used in [4, 7–10] had on the structure and chemical composition of graphene oxide in order to assess the prospects for using it to obtain graphene. In all reduction processes, graphene oxide was derived from graphite with the same chemical composition, structure, and fineness. Such research methods as X-ray energy dispersive spectroscopy (XEDS), Raman spectroscopy (Raman spectra), and scanning electron microscopy (SEM) were used to assess the quantitative and qualitative compositions of the initial and final materials, and their structural features.

II. EXPERIMENTAL

Graphene oxide was synthesized according to the Hammers method [8] from pyrolytic graphite crushed with a ball mill to form a fraction of 50–100 μm. Concentrated phosphoric (85 %) and sulfuric acids (95 %), and potassium permanganate (chemically pure), were used for this purpose. The reduction of graphene from graphene oxide was conducted in hydrazine hydrate, ethylene glycol (chemically pure), and hydrogen. The process was conducted with hydrazine hydrate using the original method described in [4].

The reduction of graphene from graphene oxide in ethylene glycol was conducted as described in [10]. Graphene was also reduced from graphene oxide with hydrogen under argon (Ar/H_2; volume ratio 1:1) at 200 and 1000°C [9, 10].

The quantitative and qualitative compositions of the investigated materials were studied via XEDS in three locations on an array. Their Raman spectra were obtained at a laser excitation wavelength of 532 nm