

Force sensitive resistor on the base of metal-carbon structures

A Tikhomirov¹ and Y Izotov² and N Sobolev³

¹ Petrozavodsk State University, Department of Physics- Engineering, Researcher, Lenin Avenue 33, Russia.

^{2,3} Petrozavodsk State University, Department of Physics- Engineering, Undergraduate student, Lenin Avenue 33, Russia.

E-mail: izotov93@yandex.ru

Abstract. The aim of the work was to explore the opportunity of creation of force sensitive resistor on the base of metal-carbon structures in size hundreds of nanometers.

1. Introduction

Methods of obtainment of nanostructures on the basis of electric discharge have significant perspectives [1]. The electric discharge in this application has some advantages such as energy efficiency, quality of the process [2, 3].

Transfer to the submicrosecond range of pulse in the electropulse discharge has a significant impact on the size of obtained powder structures [4] and results in their decrease.

The use of non-conducting liquid in the electropulse discharge has a great importance for extracting the structures obtained in it [5].

Force sensors are a very perspective direction at present. Researches of the sizes of nanoparticles metal-carbon for ensuring the best tensor effect were conducted. The aim of this work is elaboration of a sensor with the acceptable properties for the use measurement of power loading.

2. Experiment

Metal-carbon structures were obtained on basis of electropulse discharge in liquid. Solid switch has been applied in this work to get short high-voltage pulses. Presently the area of IGBT-devices is developing very fast [6] and characteristics of abovementioned semiconductor devices allow to bring together transistors consequentially and parallel in the integrated.

The experimental set-up consists of the pulse generator and the power module. The basis of pulse generator is a program microcontroller pic16f877 of Microchip with the control's clock speed of 20 MHz. The work frequency of generator is 1 kHz with the duty of pulse about 2 us. The power module is shown in figure 1.



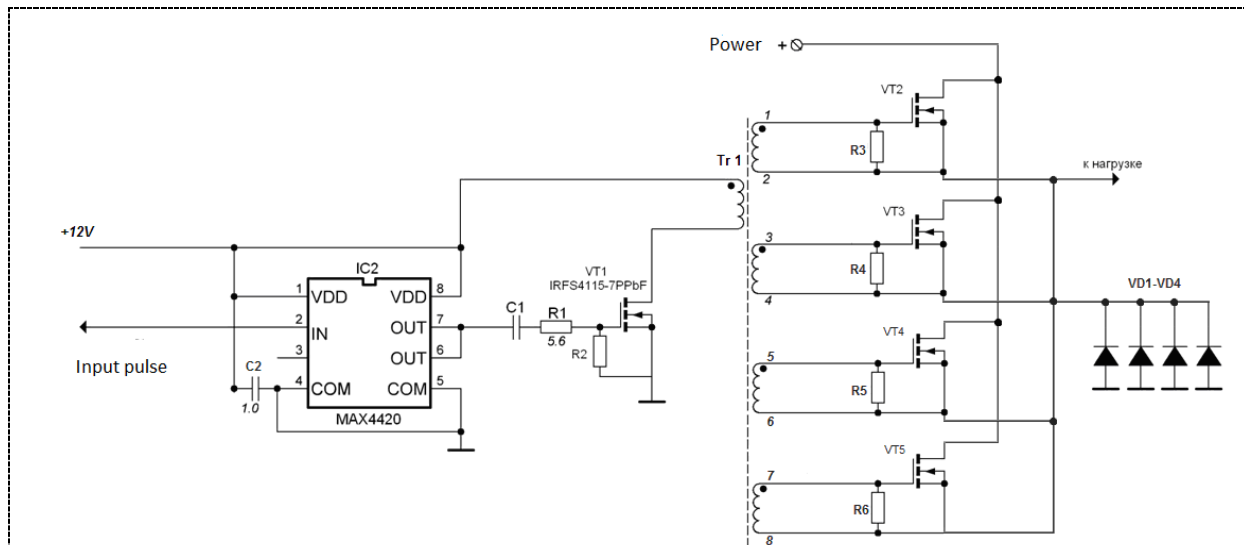


Figure 1. Power module

The signal from microcontroller goes to six ampere fast driver MAX 4420 (time of front is 25 ns on the load 2500 pF).

Taking into account low-powered outputs of microcontroller which are not able to charge gate capacity of powerful transistor VT1 (IRFS4115-7PPbF), controlling the gates of power IGBT-switch VT2-VT5. Considering the fact that to ignite the electro-erosion discharge it is not required to use high voltage, but necessary to provide discharge current the IGBT-switch is connected parallel.

The capacitor C1 is used to remove the constant component, resistor R1 – to limit current of gate charging VT1 (maximum of output current is six amperes), R2 – to discharge gate after ending electro-pulse.

Transformer Tr.1 is used to the galvanic separation between pulse generator and power module. Primary and secondary transformer coils Tr1 contain five turns each. Resistors R3-R6 are used for gate discharge when transistors close.

3. Results and Discussion

The electropulse method as aforesaid was used to obtain metal-carbon powder. Samples of molybdenum-carbides powder were obtained in erosion electropulse discharge. It find out that electric resistance of samples are depend from the time of electropulse processing. More after, electric resistance of samples is depending from mechanic force.

The samples were investigated by using scanning electronic microscope Hitachi SU1510 (Figure 2).

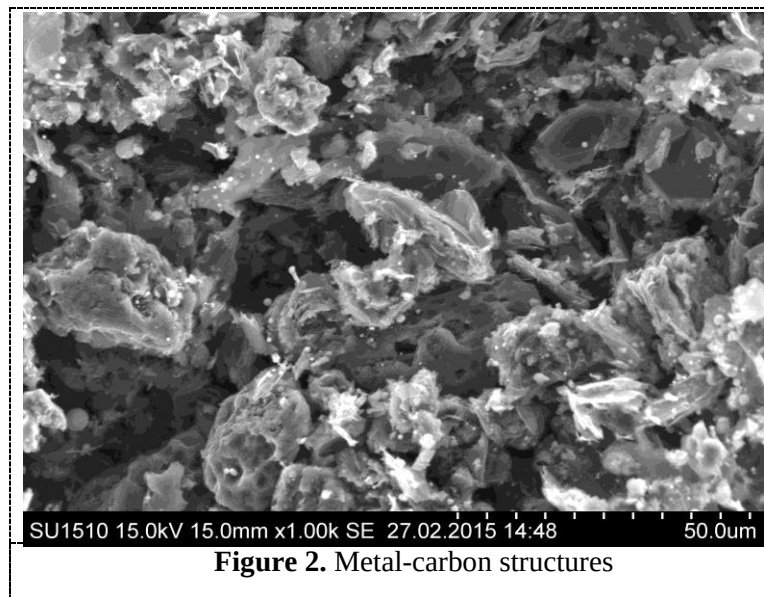


Figure 2. Metal-carbon structures

On the basis of samples of molybdenum-carbon powders the force sensors are created. In figure 3 the structural scheme of a force sensor is presented.

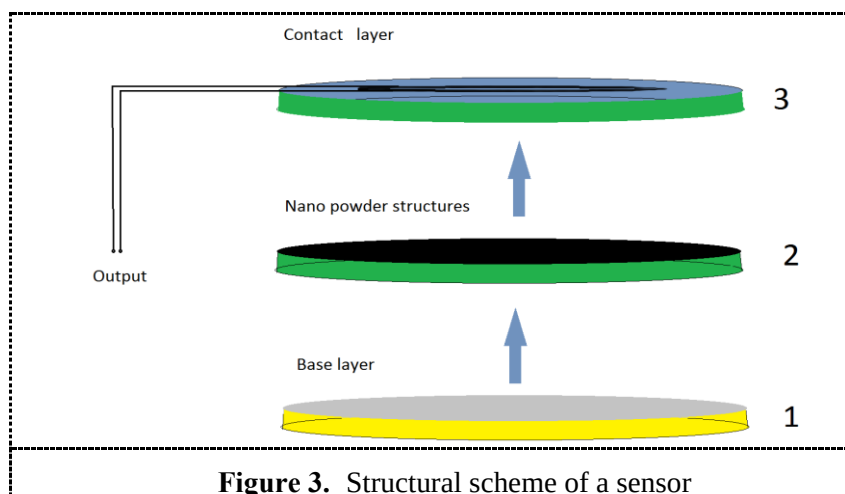


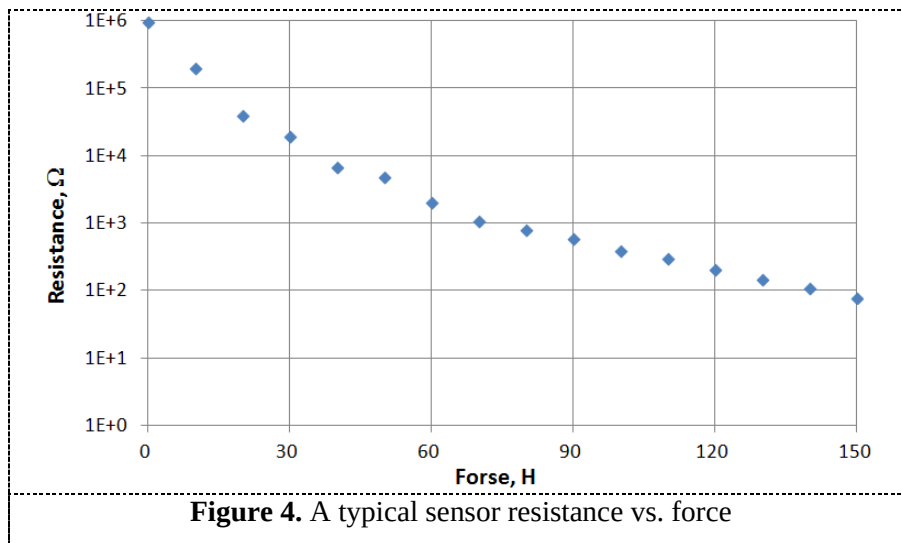
Figure 3. Structural scheme of a sensor

Where (1) is the lower layer deposited molybdenum-carbon structures on top (2) which contacts the of output (3).

The average size of obtained structures is about 100 μm . In the result of the conducted research the dependence of electric resistant on the value of the external force has been found out.

4. Force Curve

For interpretational convenience, the data is plotted on logarithmic scales. This force is influenced by the substrate and overlay thickness and flexibility, size and shape of the actuator, and spacer-adhesive thickness (the size of the internal air gap between membranes). A typical resistance vs. force curve is shown in figure 4.



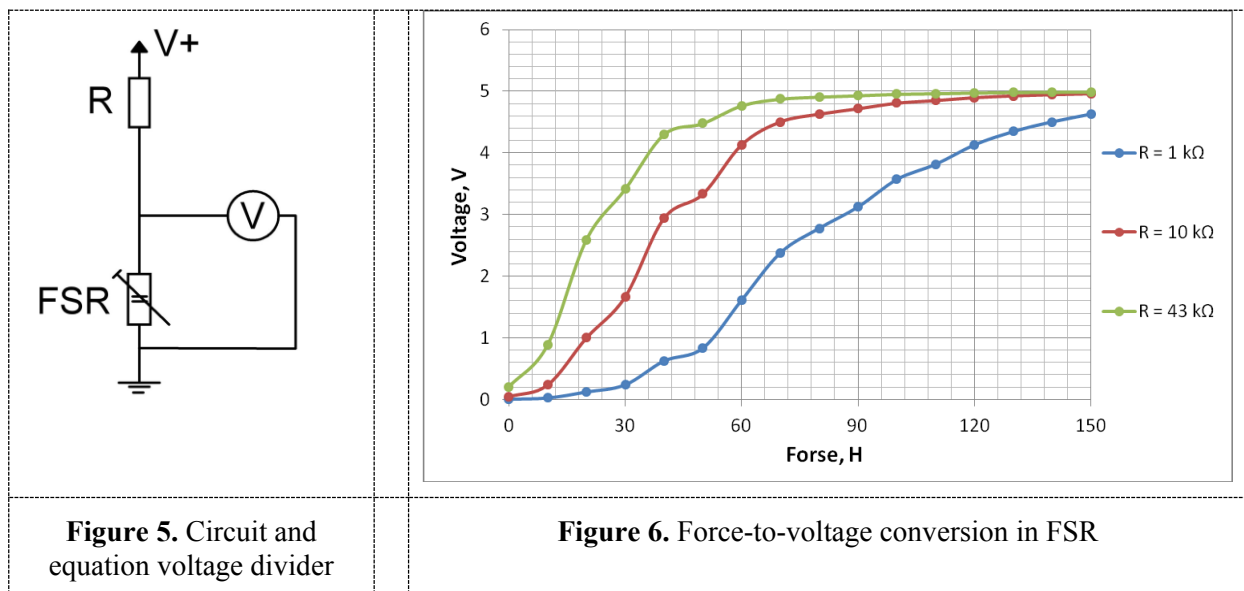
After switching on, the resistance will decrease close to exponentially dependence from force. The dependence of the electric resistance repeats again with each new cycle of applying the force.

5. Circuit FSR Voltage Divider

To convert force into voltage, force sensitive resistor sensor is attached to the measuring impedance (Figure 5) and the output voltage is described by equation:

$$V_{out} = \frac{V_+ \times R}{R + R_{FSR}}$$

If R_{FSR} and R are swapped, the output swing will increase with increasing force.



The measuring resistor, R , is chosen to maximize the desired force sensitivity range and to limit current.

In that scheme, the output voltage will decreases with increasing force (Figure 6). In figure 6 dependence of three different obtained sensors are shown.

6. Conclusion

The structure of molybdenum-carbon powders is homogenous enough, at the same time the size of carbon structures significantly exceeds the size of molybdenum structures. Molybdenum particles have a spherical form and a size of about some hundreds nanometers. The force sensitive resistor has been obtained.

The work is done by the support of Program of strategic development of Petrozavodsk State University from 2012 to 2016, Ministry of Education of Russian Federation, contract № 3.757.2014/K.

References:

- [1] L. V. Kogitov, I.V. Zaporotskova, V.V. Kozlov Perspective nanomaterial on the basis of carbon, Science journal of Volgograd state university. 10 series № 4 – 2009, p. 63-85
- [2] Abu Zaid OA (1997) On the effect of electro-discharge machining parameters on the fatigue life of AISI D6 tool steel. J Mater Process Technol 68 (1): 27-32
- [3] Ho KH, Newman ST (2003) State of the art electrical discharge machining (EDM). Int J Mach Tool Manufac 43:1287–1300
- [4] Ekmekci B, Elkoca O, Erden A (2005) A comparative study on the surface integrity of plastic mould steel due to electric discharge machining. Metall Mater Trans 36B:117–124
- [5] Puertas I, Luis CJ (2003) A study on machining parameters optimization of electrical discharge machining. J Mater Process Technol 143–144:521–526
- [6] Krishna Mohana Rao G, Satyanarayana S, Praveen M (2008) Influence of machining parameters on electric discharge machining of Maraging steels—an experimental investigation. Proceedings of the World Congress on Engineering. Vol. II, London, UK