STRUCTURE AND ELECTRIC PROPERTIES OF FILMS TIN – FULLERENE C_{60}

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Introduction

Fullerene materiology is the new scientific direction which are formed at the present time. The elaboration of the principles and receptions of the formation of fullerenecontaning and fullerenelike materials, studying of their properties are actual both from positions of basic researches, and from positions of usage such materials in various devices (solar elements, optical shutters, cold cathodes electron beam tubes, field transistors, pairs of friction etc.). As it was shown earlier [1], the thin the films of tin have anomalous dependence of specific electric resistance on thickness. At values of thickness 20 - 60 nm the specific electric resistance of tin film is lower than values for massive tin.

Technique of experiment

Composite thin films were obtained in vacuum installation VUP-4 from the combined atom-molecular streams formed by molecules of fullerene C_{60} (sublimated the fullerene powder) and the atoms of tin which were evaporated with the help of the molybdenium evaporator. The temperature of evaporators was supported constant during the evaporation and has made 673K for fullerenes and 1473K for tin. The monocrystal silicon was served, the side (111) was used as substrates. The condensation was carried aut on the substrate warming up to 423K. The residual pressure of the vapoursin the chamber at the reception of the samples did not exceed 1×10^{-3} Pa. The growth rate of the films made has 3,0 - 3,5 nm s^{-1}.

The structure and the phase of the composition films were investigated by the methods of electronic microscopy and X-ray diffraction, electric resistance was measured by the compensation method.

Results and their discussion

The thin Sn-C_{60} films have ultrafine structure. At changing of share composition of the components of the films the size of the grains decreases with theincrease of heterogeneity.

The image of thestructure of Sn-C_{60}, film received on transmission electron microscope is submitted on fig. 1.

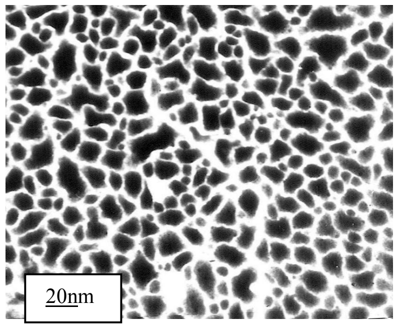

Fig. 1. TEM of Sn-C_{60} film

The submitted picture illustrates not only the small size of grains, but also the fact of an arrangement of fullerite phase on theborders of. tin grains.

At some share composition of the components in Sn-C_{60} films there are the diffraction maximums, which are unusual to tin or fullerite (fig. 2). That testifies to the presence of new phases.

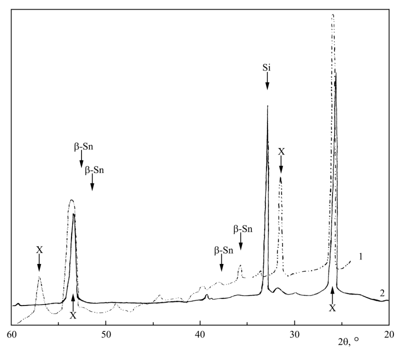

Fig. 2 X-ray test of Sn-C_{60} film:
1 - n_{Sn}: n_{C60} = 6; 2 - n_{Sn}: n_{C60} =12
The diffraction lines of unknown phases are marked by sign"X".

Detection of metal–fullelerene phases is obviously important result as it is accepted to count, that tin does not form carbide phases, and solubility of carbon in it is small (less than 0,002 at. %) [2].

Specific electrical resistance of Sn-C_{60} films changes on 14 orders at changing of mass proportion of components from 0 up to 100 %.

The temperature dependences of electrical resistance have revealed five concentration zones with different prevailing mechanisms of the charge transference. The temperature coefficient of the resistance varies over a wide range from positive up to negative. At heating and cooling the hysteresis (fig. 3) is observed.

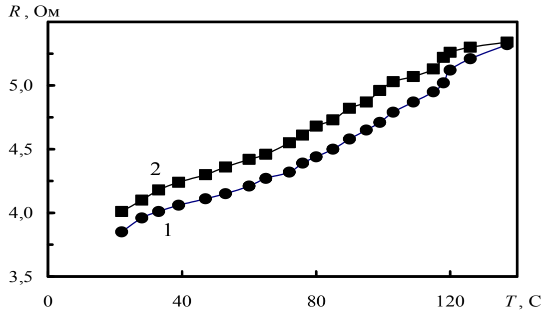

Fig. 3. Dependence of electrical resistance of Sn-C_{60} film from temperature: 1 – the curve of heating;
2 - the curve of cooling (d = 60 nm, n_{Sn}: n_{C60} = 80).

Volt-amper characteristics of Sn-C_{60} films are not linear (fig.4.).

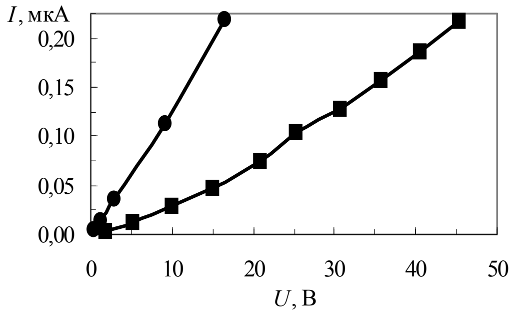

Fig. 4.Volt-amper characteristics of Sn-C_{60} films:
1 - n_{Sn}: n_{C60} = 6; 2 - n_{Sn}: n_{C60} =15.

Electrical conductivity is proportional to a square root from intensity of the electric field. Dependence of conductivity of Sn-C_{60} film from the intensity of the electric field is given on fig. 5.

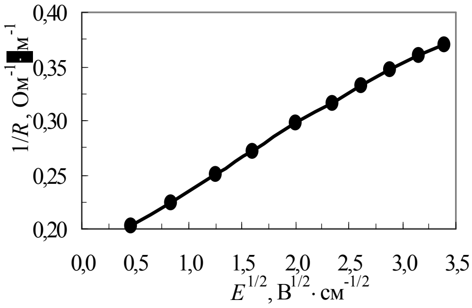

Fig. 5. Dependence of conductivity of Sn - C_{60} film from the intensity of theelectric field
n_{Sn}: n_{C60} = 6

The observable activation of conductivity by theelectric field testifies to the presence in the films both metal and dielectric (semiconductor) phases. The structure of films represents "islelike" which are shown on fig.1.

Conclusions

1. It is established a structuring role of fullerenes at joint condensation of tin and fullerenes.
2. At joint condensation of tin and fullerenes for some share cjmpositions of components the chemical interaction of atoms of tin with fullerene C_{60} molecules and the formation the of fulleride Sn_xC_{60} are observed.
3. At changing of share composition of the components the specific electrical resistance changes on 14 orders, thus five concentration zones with different prevailing mechanisms of the charge transference are revealed.
4. For the majority of share compositionsof components of Sn-C_{60} films have the nonlinear volt-amper characteristics, their conductivity is activated by the electric field.

References

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2. Elliot R.P. Structures of double alloys. V. 1. M.: Metallurgy, 1970. - 456 p. (in russion)