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1992 J. Phys.: Condens. Matter 4 L513

(http://iopscience.iop.org/0953-8984/4/40/002)

J. Phys.: Condens. Matter 4 (1992) L513–L514. Printed in the UK

LETTER TO THE EDITOR

A possible interaction between non-alkali metals and C_{60} thin films

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Received 14 July 1992

Abstract. By measuring the resistance *in situ* during the deposition of metal–C_{60} multilayer thin films on sapphire substrates at room temperature, we find that the resistance decreases sharply when adding C_{60} on some metal layers. There are two possible explanations: one is the formation of a conduction layer of metal- (Sn-, Ba-, Ga-) doped C_{60}; the other is a bonding interfacial interaction between the metal and C_{60} layers, which may result in a better continuous metal layer.

The discovery of alkali-metal-doped C_{60} superconductors [1] has stimulated widespread interest in the properties of these materials. Besides the alkali metals, researchers have paid much attention to the search for and study of the properties of non-alkali-metal-doped C_{60} superconductors. Recently, Kortan *et al* successfully synthesized a calcium-doped C_{60} superconductor [2], which was the first non-alkali-metal-doped C_{60} superconductor. The XPS study also showed that Ba and Sr can react with C_{60} to form new metallic phases, which were believed to be candidates for exhibiting superconductivity [3].

Here we report experiments on several non-alkali-metals– (Sn–, Ba–, Ga–, In–, Ag–) C_{60} multilayer thin films. We find that there is some evidence of possible interactions between Sn, Ba and Ga with C_{60} thin films.

The metal–C_{60} multilayer thin films were deposited by high-vacuum sublimation on sapphire substrates at room temperature, in a vacuum of 2×10^{-4} Pa. Prior to evaporation, four contacts for four-terminal measurements were made by evaporating Ag, and connecting Cu wires with silver paint.

The evaporation order is C_{60} (50 Å), metal (15 Å), C_{60} (50 Å), and so on. In the evaporation process, we measured the resistance *in situ* by a two-probe method. The threshold resistance that we can detect is 200 MΩ. The film thickness was monitored by a quartz oscillation device.

We find that the resistance decreases sharply when adding C_{60} on Sn, Ba and Ga layers. With the increasing thickness of the C_{60} layer, the resistance drop becomes slow, and the resistance finally becomes constant when the thickness of the upper

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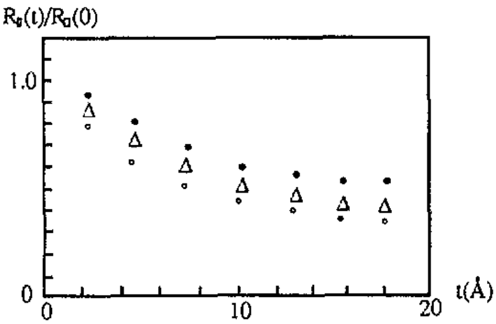

Figure 1. Reduced sample resistance per square versus the average thickness of the upper layer of C_{60} added to different Sn layers: ○, the first layer; Δ, the second layer; ●, the third layer.

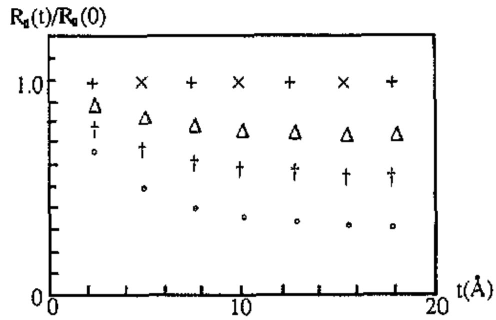

Figure 2. The sample resistance per square versus the average thickness of the upper layer of C_{60} added to different metal layers: +, Ag; ×, In; Δ, Ga; †, Ba; ○, Sn.

C_{60} layer is above 50 Å. The resistance drop when adding C_{60} on the Sn layer is illustrated in figure 1. Usually, the resistance drops more sharply when adding C_{60} on the first metal layer than it does for the second one.

Since the pure C_{60} thin film is an insulator, it is astonishing that some metal thin films became 'more conducting' on neighbouring with C_{60} (from above). So far we have considered two possible reasons for this exotic phenomenon: the first is the formation of a conduction layer of alloyed C_{60}; the other is the existence of a negative interfacial energy between metal and C_{60} layers, which may result in a better continuous metal layer.

For comparison, we also deposited C_{60}–Ag and C_{60}–In multilayer thin films. In contrast to the case for C_{60}–Sn, C_{60}–Ba and C_{60}–Ga multilayers, we found no change of resistance on adding C_{60} in the C_{60}–Ag and C_{60}–In multilayer systems. The effects of adding C_{60} on different metallic thin films are illustrated in figure 2 for a reduced scale. The reason for the difference in behaviour of such systems is not clear at present. Further spectroscopic and microstructural studies of these multilayer systems are being carried out in the hope of achieving an understanding of the mechanism of the C_{60}–non-alkali-metal interactions.

The authors wish to thank Professor Jinlong Zhang for stimulating discussions. This work was supported by the National Centre for Research and Development on Superconductivity and the Graduate Science Foundation of China.

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