

Evidence for Josephson-coupled superconducting regions at the interfaces of highly oriented pyrolytic graphite

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The first observation of superconductivity in doped graphite goes back to 1965 when it was observed in the potassium graphite intercalated compound C_8K [1]. A considerable amount of studies had reported this phenomenon in intercalated graphite compounds or doped graphite [2-4], however the superconducting properties of pure graphite are still under discussion. Indirect evidences for superconductivity at graphite interfaces have been recently published [5-6]. In order to better understand their properties and confine the path of the input current to go through some of the possible superconducting areas, we prepared micro structured samples (Lamellas) from pure highly oriented pyrolytic graphite. By reducing the dimension in the in-plane configuration to $\sim 200\text{nm}$ we can measure the electrical response of graphite interfaces. We obtained evidence for the existence of Josephson-coupled quasi two dimensional superconducting regions (patches) located at internal interfaces of the oriented graphite samples. Temperature dependence of the voltage (Figure 1), as well as $I(V)$ characteristic curves (Figure 2) indicate that superconductivity exists even above 150K. The negative values obtained for the measured voltages can be understood using a simple Wheatson bridge model. The resistor elements of the bridge will correspond to the effective resistances of the inhomogeneous current paths inside the samples. Ambegaokar and Halperin theory [7] is used to describe the $I(V)$ characteristics of the superconducting patches contribution within the model. The results support the view that HOPG is a system with interfaces containing non-percolative superconducting domains immersed in a semiconducting graphene-based matrix.

References

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Figures

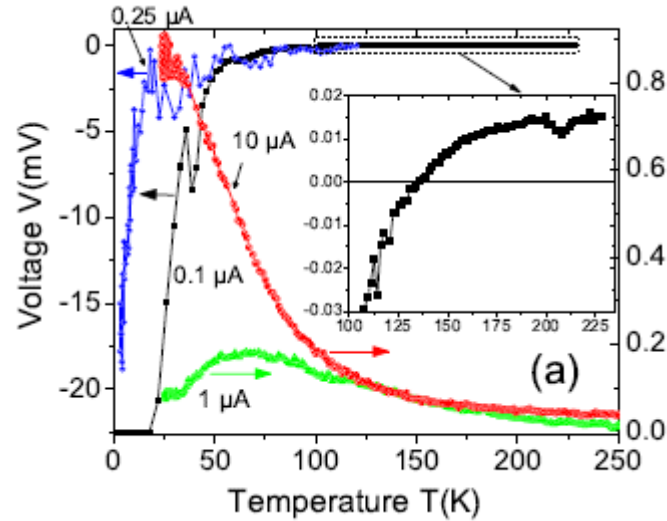


Figure 1. Voltage vs. temperature measured at four different current amplitudes. The right y-axis applies for the results at 1 and 10 μA . The inset shows the results for 100 nA input current in the high temperature region. Note that the change in the voltage is observed even above 150K.

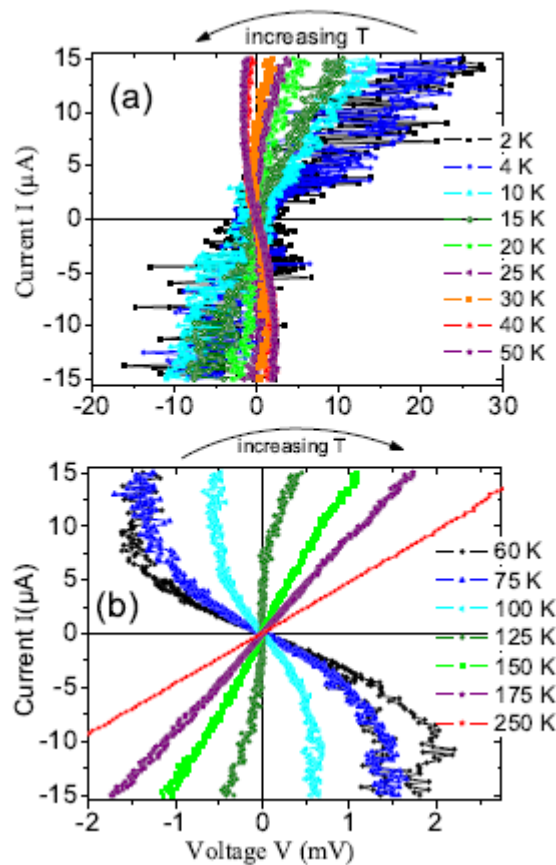


Figure 2. Current-voltage curves at different temperatures. (a) A noisy behavior is found at low temperatures ($T \leq 10\text{K}$) due to the heterogeneous properties and coupling between the superconducting patches. Above this temperature the noise reduces and the nonlinearity shows a “negative resistance” part that increases up to 60K. (b) Above 60K the nonlinearity gets weaker reaching a linear behavior above 200K.