# DEFECTS AND CONDUCTIVITY OF DNAS

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Conductor or insulator? The debate about the conductivity of DNA have been recently revived due to contradictory results of transport measurements on a small number of molecules deposited on a substrate and connected to metallic electrodes, and an answer to this question is important for DNA based molecular electronics. In several works it was observed that double-stranded DNA molecules are conducing (semicoducting, metallic or even superconducting due to proximity induced superconductivity) [1-3]. However in other works DNA was found to be insulating [4], even when the molecules had perfectly ordered base pairs.

In this report we argue the conductivity of DNAs dependes on defects in the molecules. At first we consider the global defect of the DNAs structure due to the interaction of the molecules with the underlying substrate. For most commonly used substrates like mica or silicon oxide the interaction between the molecule and the surface is very strong and induces a very large compression deformation of deposited DNAs. The thickness of such compressed DNAs is 2–4 times less than the diameter (about 2 nm) of native Watson-Crick B-DNA [4]. Here we confirm the insulating character of DNA on such substrates. On the other hand when the substrate is treated (functionalized) so that deposited molecules keep their original thickness, we find that they are conductors, both from conducting AFM (fig.1) and transport measurements on molecules connected to platinum electrodes. This conductivity persists down to very low temperature (0.1 K) where it exhibits a non-ohmic behavior with a power law singularity in the bias dependence of the differential resistance typical of one-dimensional conductors with Coulomb interactions between electrical carriers [2].

The local defects of DNAs like "bubbles" can also influence the conductivity of the molecules. The existence of "bubbles" has been confirmed experimentally [5], and the biological aspects of these local denaturations were discussed in a number of studies. Local deformations should cause breaking of a long-range order in the DNA structure (i.e., interruption of the parallel base-pair (bp) stackings) similar to an order breaking in solid bodies due to the dislocation introduction. However, their influence on conductivity has not been properly addressed until now. In this report, we present the temperature-dependent conductivity (fig.2) and structural evolution monitored through Raman spectroscopy measured on the DNA-lipid cast film between physiological and denaturation temperatures. We observed a substantial reduction in the DNA conductivity due to premelting effects starting at temperature as low as 40◦C, lending support to the theoretical inference on the importance of the long-range parallel bp stacking in DNA for the electrical conduction [6].

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**References:**

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**Figures:**

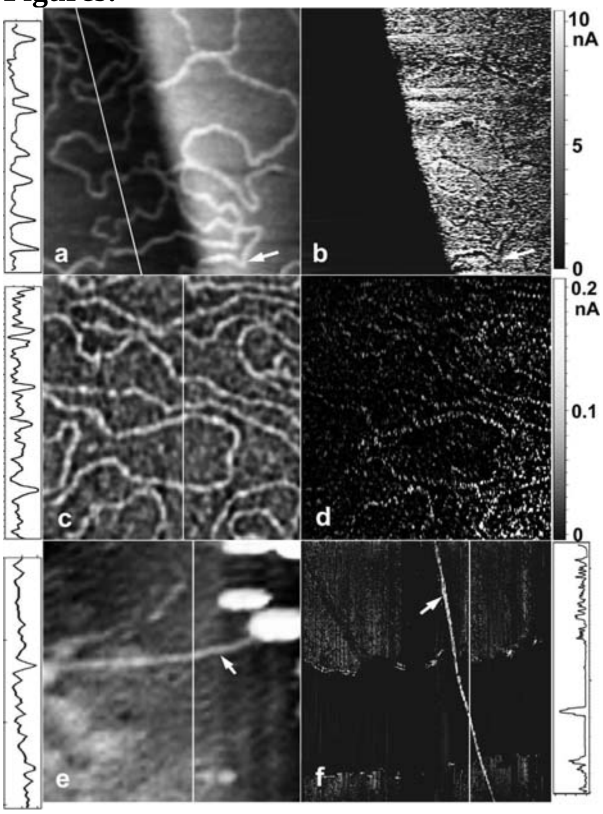


FIG. 1. AFM (left) and SRM (right) images of DNAs: (a) AFM image of DNAs on the clean substrate without penthylamine; (b) SRM image of the same molecules (right bright part of a and b images is Pt); (c) AFM picture of DNAs on the substrate treated by penthylamine; (d) SRM image of the same molecules, Pt electrode is outside of the image; (e) AFM image of a DNA combed across the slit between Re/C electrodes on mica; (f) SRM image of a rope of DNAs combed between Pt electrodes on mica. On the left- and right-hand sides of the image there are profiles of DNAs and current scales of SRM (voltage was up to 0.23 V) images, respectively. Note that when (b) is plotted on the same current scale as (d), the DNA molecules on the mica still appear as black as the mica substrate.

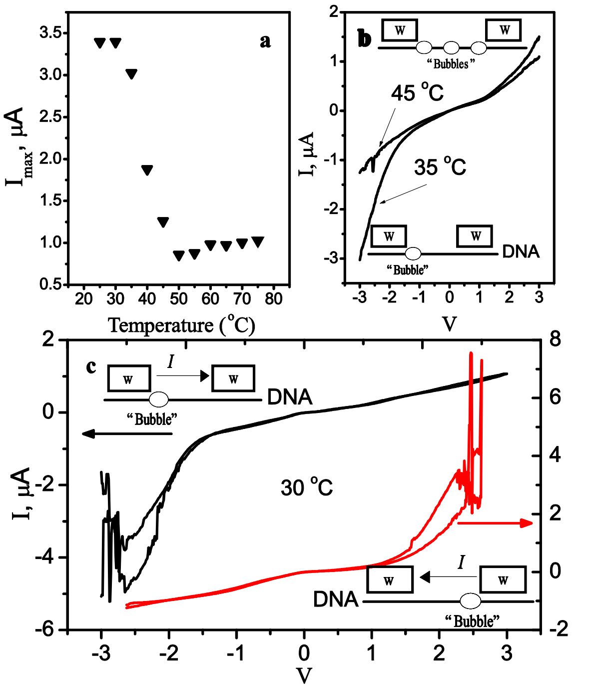


FIG. 2. Temperature-dependent conductivity measurements under luminosity: (a) temperature dependence of Imax, (b) I-V characteristics of the DNA film at 35 and 45◦C. The insets show the increasing number of bubbles with a temperature, (c) irreversible I-V characteristics (at 30◦C) of the DNA film which had been subjected to a high bias voltage at 80◦C with opposing polarities. The insets show the assumed schematics of the bubble type defect movements inside the DNA molecules at 80◦C.