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# A Field-Effect Transistor for Phonons Based on a Single Molecule

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**Abstract** – Manipulating phonons with the same degree of control we manipulate electrons has always been an elusive dream for physicists. In this work, we propose a practical realization of a single-molecule phonon field-effect transistor based on controlling the thermal conductance due to phonons in an ionic polymer. Our proposal has the following very attractive features: (1) The phonon conductance is controlled by a back-gate electric field; (2) It works at the nano or molecular scale; (3) It operates at achievable temperatures and electric field magnitudes.

Manipulating phonons with the same degree of control we manipulate electrons has always been an elusive dream for physicists. The electronic transistor was invented in 1947 [1] and it has revolutionized our lives since them, but so far there are no experimental realizations of its phonon counterpart. However, the potential range of applications that could arise from taming the flow of thermal current is so broad that it justifies a strong pursue of this goal.

Nanoscale science and engineering offer some hope in realizing this dream. The development of sophisticated lithography techniques at the nanoscale made possible a landmark achievement in this field in the year 2000 [2]: The measurement of the quantum of thermal conductance, theoretically predicted two years earlier [3]. Also, the recent realization of a thermal rectifier using mass-asymmetric carbon nanotubes was very promising in the context of building thermal devices [4]. However, the realization of an *active* device such as a transistor remains an open subject.

In this work, we propose a practical realization of a single-molecule phonon field-effect transistor based on controlling the thermal conductance due to phonons in an ionic polymer. Our proposal has the following very attractive features:

(1) The phonon conductance is controlled by a back-gate electric field. This is highly desirable, since electrical operation allows much faster switching times and more precise control than mechanical switching.
(2) It works at the nano or molecular scale. This is important because, as we mentioned, the degree of control and measurement sensibility of the thermal energy flow is greater at this scale. Besides, the proposal can be implemented with the existing technology used in the field molecular electronics.
(3) It operates at achievable temperatures and electric field magnitudes.

Our device is schematically shown in Fig. 1. Thermal conductande modulation is achieved by the coupling of an external electric field to the permanent dipole moments of the monomers which changes the dispersion of torsion vibrational modes.

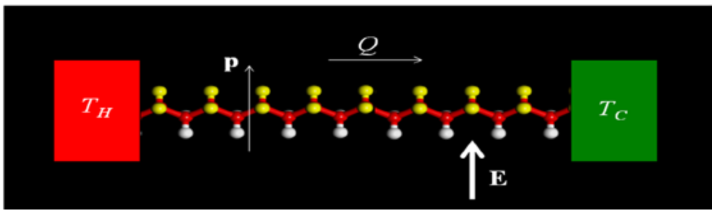


**Figure 1:** Schematic representation of a single-molecule phonon field-effect transistor.

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