The Way to Thermal Computers Utilizing Near-field Thermal Radiation. Mahmoud Elzouka[1] and Sidy Ndao, [1]Me Mechanical and Materials Engineering, University of Nebraska-Lincoln, W317.4C Nebraska Hall, melzouka2@unl.edu, sndao2@unl.edu.

Abstract: Electronics can't perform in extreme temperatures and extensive radiation environments, which prevent us from exploring deep in our Earth or our own solar system (e.g., Venus). This mandates developing alternative computing technologies, which can be classified under one of two main categories: material research (e.g., alternative wide bandgap semiconductor materials such silicon carbide) and NanoElectroMechanical memory and switches, both of which still dependent on semiconductor properties and/or electricity.

Our research group has introduced the concept of near-field NanoThermoMechanical memory [1] and rectification [2], which can lead eventually to a computer that can run on heat, and its data are stored in hot or cold logic states (instead of zero and ones in electronics). We have achieved thermal rectification and memory functions through nonlinear heat transfer between two terminals; by coupling the near-field radiative heat transfer [3] between two terminals with the expansion in the microstructures that support the terminals, which in turn manipulate the size of the micro vacuum gap between the terminals.

We have demonstrated the thermal memory functionality numerically [1], and thermal rectification experimentally [2] at temperatures as high as 600 K, with a maximum rectification of 10.9%. We have proven numerically that we can boost the rectification to 2500% by including meshed photonic crystal structures [4] to our NanoThermoMechanical rectifier. With this high thermal rectification value, we can claim our thermal rectifier to be a thermal diode.

Here in this presentation, we are demonstrating the ability of our NanoThermoMechanical rectifiers to be able to work together and perform logic operations. We simulate a simple logic circuit that is composed of our NanoThermoMechanical rectifiers with meshed photonic crystals (i.e., thermal diodes). Our goal is to show that our logic circuit can achieve logic operation with enough contrast in output logic states to be identifiable, and with enough tolerance to input logic state.

References:

[1] M. Elzouka, S. Ndao, Near-field NanoThermoMechanical memory, Appl. Phys. Lett. 105 (2014) 243510. doi:10.1063/1.4904828.

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[3] J.-J. Greffet, Revisiting thermal radiation in the near field, Comptes Rendus Phys. 18 (2017) 24–30. doi:10.1016/j.crhy.2016.11.001.

[4] Meshed doped silicon photonic crystals for manipulating near-field thermal radiation, J. Quant. Spectrosc. Radiat. Transf. 204 (2018) 56–62. doi:10.1016/J.JQSRT.2017.09.002.

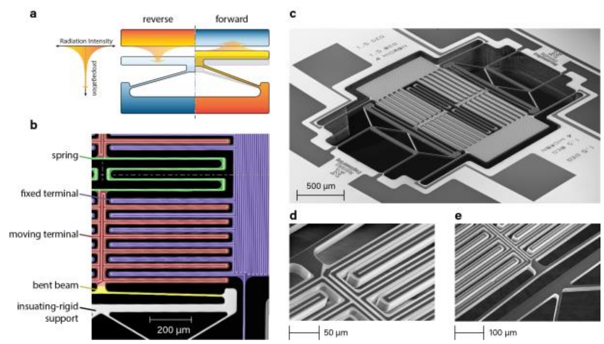

Figure 1: NanoThermoMechanical Rectifier [2]

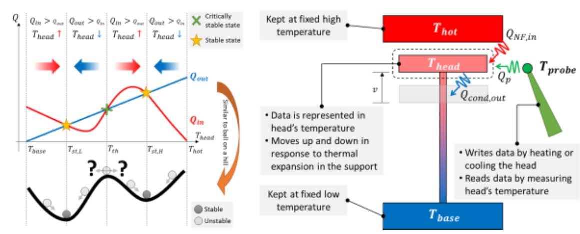

Figure 2: NanoThermoMechanical Memory [1]

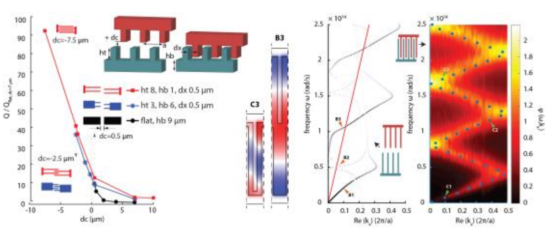

Figure 3: Meshed Photonic Crystals for Enhanced Eectification [4]