MAPPING HEAT DISSIPATION MECHANISMS TO IMPROVE ELECTRONIC DEVICES

MARENOSTRUM5 GPP

Led by



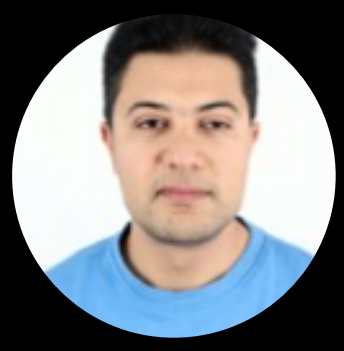
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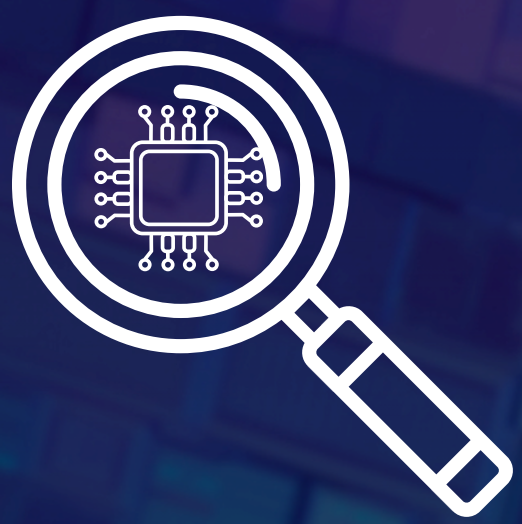


H. REZGUI

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1 HOW CAN ELECTRONIC DEVICES BE IMPROVED?

Modern telecommunication systems rely on **miniaturized devices** that combine **electronic, optical, and mechanical** functions on a single platform



As these components **shrink** to enable faster, low-power processing, managing **heat and energy loss** becomes a critical challenge

Engineering the microstructural properties of materials like **nanocrystalline silicon** offers a promising solution to **minimize energy dissipation**



WHAT IS THE ROLE OF GRAIN BOUNDARIES? 2



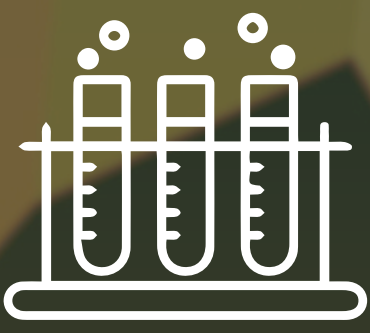
Physical properties in nanocrystalline materials are **governed by grain boundaries**, the interfaces where individual crystals meet

These boundaries concentrate **defects and trap energy** in localized vibrational modes known as **phonons**, which are quantized lattice vibrations



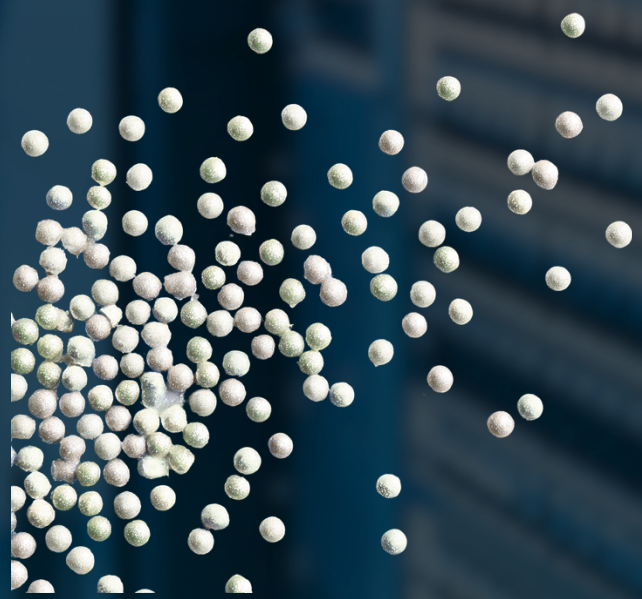
Understanding how these **trapped phonons alter thermal transport** is essential to minimize energy dissipation

However, **experimental characterization** at these tiny scales is **extremely challenging**



3 THE ROLE OF MACHINE LEARNING AND HPC

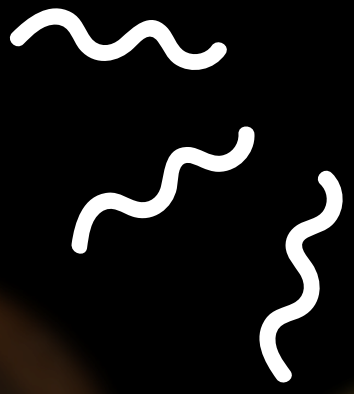
To solve this, researchers use **advanced Machine Learning models** trained specifically to map the physical behavior of grain boundaries



By using HPC resources, it becomes possible to **accurately simulate the movement of atoms** near to these boundaries

These powerful simulations can even **reveal subtle vibrational behaviors** of atoms, eliminating the need for trial-and-error **experimental tests**

WHAT DID THE SIMULATIONS SHOW? 4



The models identified **unique vibrational modes trapped at grain boundaries**

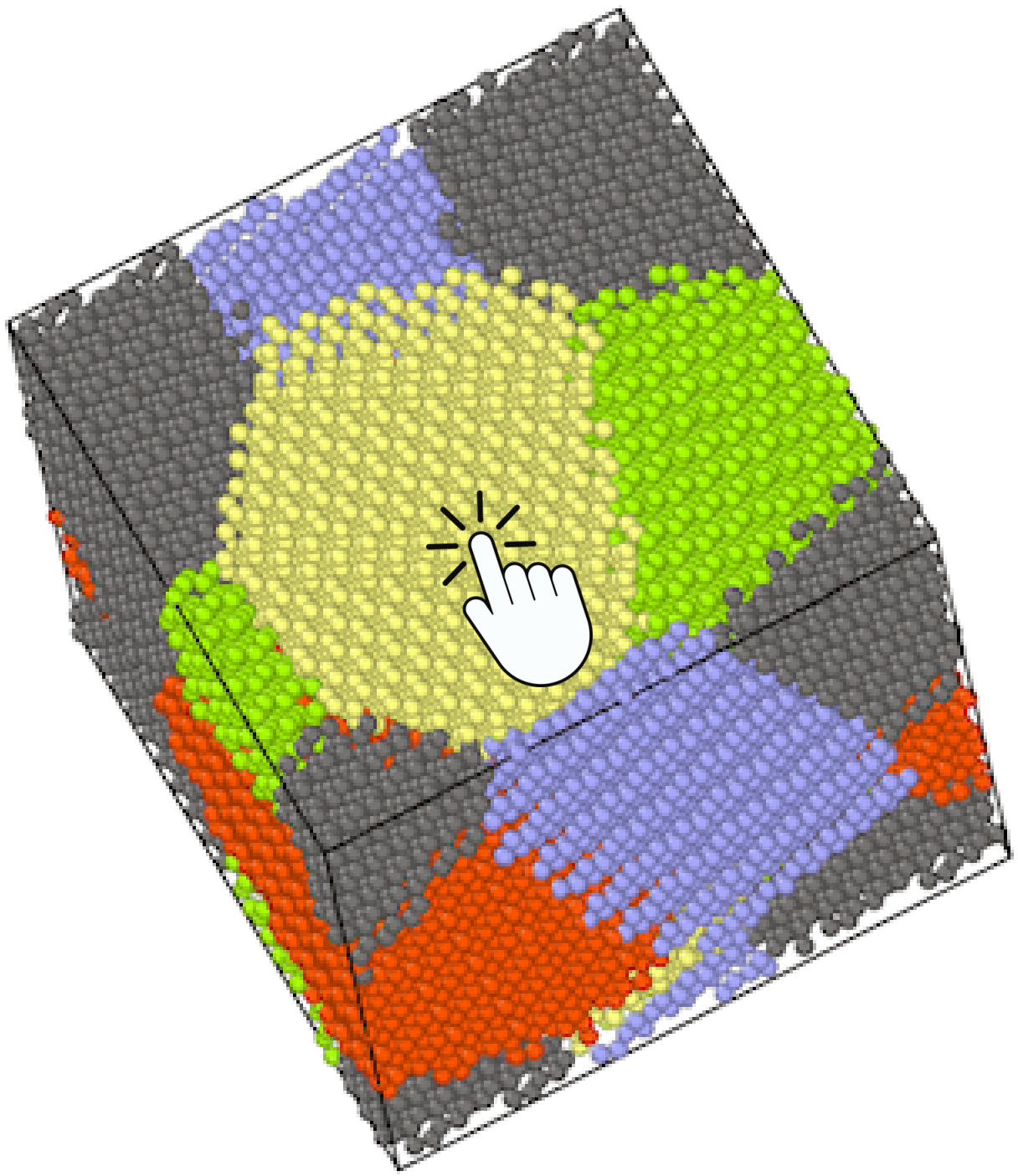
These vibrations **do not easily exchange energy** with the rest of the material, **preventing heat from dispersing** naturally





Instead, energy transfers only to nearby low-energy modes, leading to **localized heat accumulation** at grain boundaries

These insights open new paths to achieve **smaller, more efficient** devices



Animation. 3D model of polycrystalline silicon.

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