UC San Diego

Department of Nano Engineering

Nano 120B

Final Report - Group 5

High Thermal Conductivity Graphene/Diamond and Diamond/Ecoflex Composites for Use as Thermal Interface Materials

Anjali Jakasania

Colin Stengle

Kian Haghnazari

Frank Dininno

Quad Chart

Problem / Need

• Solid phase, reusable, environmentally friendly thermal interface materials
• Top of the market liquid metals have thermal conductivities of ~ 50 W/m·K

• Market standards are single use, environmentally incompatible, and consist of materials toxic to humans.

Approach / Solution

• Leverage thermal properties of diamond and graphene to create solid phase thermal interface materials
• Biodegradable, theoretical conductivity 5x that of liquid metal
• Synthesis of diamond/graphene composite is successful (71.68 W/m·K), compression/mechanical optimization is necessary

Impact / Benefits

• Reusability increases the lifespan of these composites, offering an environmentally friendly alternative to typical thermal pastes.
• Increased heat flow allows chips to operate at cooler temperatures, increasing efficiency and design flexibility.
• More efficient devices will allow more computations per unit power, ultimately helping grid sustainability.

Current Status / Next Steps

• Graphene/Diamond and Diamond/ecoflex composites have been made (71.68 W/m·K and 49.64 W/m·K)
• Diamond/ecoflex composite is mechanically robust, fit for implementation in devices
• Optimization of our graphene compression process is needed to maximize compression and vertical alignment of nanoplatelets, increasing performance and mechanical stability

Purpose

Modern computing and power devices generate substantial heat during operation due to resistive losses in their circuitry. Efficient thermal management is critical to ensure device reliability, energy efficiency, and design miniaturization. Thermal interface materials (TIMs) play a vital role by improving thermal contact between heat generating components and heat sinks, replacing air gaps with materials that have superior thermal conductivity.

The purpose of this project is to design and characterize solid phase thermal interface materials that combine high thermal conductivity, low elastic modulus, reusability, and environmental compatibility. Motivated by the exceptional thermal properties of graphene and diamond, whose intrinsic thermal conductivities exceed 2000-4000 W/m·K, we fabricated a series of composite materials of two different types: diamond/ecoflex composites with the ecoflex acting as a matrix with diamond conductive particles—similar to the working mechanism of typical thermal pastes–and graphene/diamond composites. Through experimental characterization of thermal performance and comparison with conventional TIMs, our goal was to evaluate their feasibility for future integration into electronics cooling applications.

Background & Approach

Thermal interface materials aim to fill the air gaps between the heat generator and heat sink with a material that has a thermal conductivity greater than air, ultimately maximizing heat flow from the power

Synthesis of Graphene/Diamond Films