



**CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY**

Name(s) Alec A. Balandin	Project Number J1303
Project Title How Does Graphene Implanted in Thermal Paste Affect Its Heat Conduction Properties?	
<p style="text-align: center;">Abstract</p> <p>Objectives/Goals I wanted to learn how graphene could affect the heat conduction properties of commercial thermal paste, and understand if graphene can be used for improving heat removal from computers.</p> <p>Methods/Materials I used commercially available solution of multi-layer and single-layer graphene and thermal paste to prepare composites with graphene. To measure the thermal conductivity, I used the "Hot Disk" and "Laser Flash" techniques. The concentration of graphene in the thermal paste was independent variable. The thermal conductivity was measured at different temperatures.</p> <p>Results My results have shown that addition of single-layer and multi-layer graphene increases the thermal conductivity of the commercial thermal paste from 1 Watts per meter per Kelvin (W/mK) to 35-50 W/mK. This supports my hypothesis that graphene would increase the thermal conductivity of the thermal paste. I found that multi-layer graphene in composites produces stronger effect than single-layer graphene. I also observed that the thermal conductivity of the thermal paste with graphene increases with temperature.</p> <p>Conclusions/Discussion My hypothesis was supported by the experimental data. The thermal conductivity of composites with graphene increased. This improvement can be explained by excellent thermal property of graphene and its good mixing in composites. This project expanded our knowledge of thermal properties of composites with graphene. The results suggests that commercial thermal pastes can be improved by adding graphene. This method can possibly innovate computer and cell phone technologies by preventing overheating of the electronic components inside the gadgets.</p>	
Summary Statement The project demonstrated that atomically-thin graphene can improve heat conduction properties of thermal paste and facilitate heat removal from computers.	
Help Received I used equipment for mixing composites and measuring thermal conductivity in the University of California # Riverside. My mentor was Fariborz Kargar, Research Assistant and PhD Candidate.	