V. Results from Prior NSF-Funded Projects

Dr. Zhenhai Xia has completed four NSF grants (0923530, 1000768, 1343270 and 1212259), and has two ongoing NSF projects (1266319, and 1363123). The award most closely related to this proposal is 1212259: Integrated Studies of Interfaces in Nanocomposites and Nanoimprinting*,* $250,000, 9/1/11–8/31/14. The objective of this project is to study the fundamental interfacial friction mechanisms and to develop new design concepts for both nanocomposites and nanoimprinting. A unique approach will be developed to quantitatively measure the interfacial friction in nanofiber reinforced metal/ceramic nanocomposites and in metal nanoimprinting. The aim is to demonstrate the principles of controlling the interfaces to achieve strong, tough nanocomposites, and non-lubricated nanoimprinting technology.
Intellectual Merit: Our research answers a fundamental question in composites: is the friction law derived in macroscope still valid at nanoscale? We are the first to prove that the friction law for microscale composites can be applied in nanoscale but modified by nanoscale interaction. The result has significant impact on the concept of nanoscale friction. Our findings point toward new directions in design of strong and tough nanocomposites.
Broader Impacts: Three graduate students, one visiting scholar and one undergraduate student conducted research in projects. One MS and two Ph.D. students graduated and obtained their degrees. Besides, four high school students worked in our lab; and have chosen engineering as their major in the college studies. Other accomplishments include: 21 journal papers [61-81]. More than 20 invited talks have been delivered in the past four years at universities and conferences worldwide.

Dr. Liming Dai has completed 10 NSF grants (0456394, 0438389, 0740507, 0708055, 0609077, 0943120, 1000768, 1047655, 1106160, 1343270) and has 2 ongoing NSF project (1266295, and 1400274). The award most closely related to this proposal is: 1047655/NIRT: Fabrication of Carbon Nanotube Dry Adhesion, $1,000,000, 3/3/10–3/2/14, (in collaboration with Pulickel Ajayan and Ali Dhinojwala). The primary objective of this research is to fabricate vertically aligned carbon nanotube array for dry adhesives. Various manufacturing methods were developed for low-cost and scalable production of vertically aligned carbon nanotube dry adhesives, which lead to a Science paper [37] and many other journal publications.
Intellectual merit: Our research focuses on the development of synthetic methods for the preparation of polymers and nanomaterials with well-defined structures and functionalities. Materials of interest include, but not limited to, vertically-aligned carbon nanotubes as gecko-foot mimetic dry adhesives, N-doped vertically-aligned carbon nanotubes, and graphene sheets doped with various heteroatoms for energy conversion and storage devices. Through the full or partial supports from the above-mentioned NSF project, I, in collaboration with the PI, have developed the world strongest CNT dry adhesive, and the efficient carbon-based metal-free ORR catalyst. These results provide new paradigms for the design and development of novel CNT materials as dry adhesives and metal-free carbon-based ORR catalysts for solving various energy and biomimetic/bioinspired problems.
Broader Impacts: Over 50 papers have been published from those projects since 2010 [82-136]. About 40 invited presentations have been made at National and International conferences. In the meantime, 5 PhD students have graduated by conducting these projects. In addition, 5 postdoctors have been trained on the projects over the years. A number of high school and undergraduate students visited our labs or did research work in summer times; two of the high school students have chosen engineering as their major in the college studies.