Graphene and New 2D Materials: Industry Needs and Commercialization

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Abstract

Lockheed Martin (LM) is seeking to establish a multidisciplinary and internationally collaboration devoted to the design and development of advanced two-dimensional (2D) layered materials. The effort will synergistically integrate each LM business units with academic, research institute, government and leading national/international Industries. We will review industrial needs for defense and IT communities and define applications in key strategic areas for national interests in materials, devices and systems. The successful collaborations between academia, government and industry will yield opportunities in nanomaterials, define transformational goals and impact to nanotechnology. The talk outlines include:

• *Overview Industry Needs* • *Review Achievements in Graphene* • *New 2D Material Developments*
• *Outlook / Opportunities in 2D Materials* • *Commercialization and Challenges*

2D materials exhibit a variety of unique properties different from bulk that will enhance the performance of existing technologies and enable future potentials. The outstanding characteristics also suggest that these materials could provide new possibilities in analog and digital electronics, optoelectronics, multifunctional sensors and actuators, shielding, energy storage/harvesting, anti-corrosion, oxidation, abrasion, friction, extreme environmental tolerance, biocompatibility, and transport properties, especially with ultrathin scales. However, the fundamental study of synthesis, integration, properties, processing techniques and scale-up ability of these novel material systems is still in development phases and required for the success of scientific innovation. The developments of novel 2D materials such as graphene, MoS2, WS2, hBN, and WSxSe1-x should leverage and ensure close academic-industrial collaborations. Furthermore, the cross-cutting knowledge and close industrial partnership between the equipment manufacturers, material suppliers, semiconductor companies, small businesses and large corporations will result in a unique synergistic alliance to further exploit the unprecedented physical properties of 2D nanomaterials and revolutionize multifunctional technologies. The pursuits should have the following activities: performing transformational and application oriented R&D, developing IPs, establishing low cost and high quality nanomanufacturing capabilities.

For this effort, LM's advanced materials and nanotechnology develop ultimate visions to: Enable affordable and highly scalable applications in air, space, on land, at sea with multifunctional performance superior to conventional materials; Shift paradigms in multiple industries like energy, sensing, and computing as well as fundamental manufacturing; Generate materials-by-design capabilities for unmatched technological advantage in our core market, blazing major trails into multiple adjacent and horizon markets. Our clear missions are to coordinate and leverage advanced materials and nanotechnology development efforts and capabilities to capture and maintain technological leadership and drive technology transition consistent with defense priorities and key promising adjacencies that will both strengthen our leadership position and support continuing, cutting-edge research and development in this domain. The major focus development areas for novel 2D materials cover Nanomaterials and Manufacturing (revolutionary multifunctional structures, enable low-cost manufacturing); Energy (cables and wiring, advanced batteries and supercapacitors); Sensors and Electronics (broad-band infrared sensors, flexible electronics); Modeling and Advanced Computations (enable bio-mimetics; computers as powerful as the brain); Adaptation and Stealth.

We will illustrate the following three approaches: Advance S&T Discovery -Enable exploration for new technology development to strengthen our ability to provide innovative and affordable solutions into our core products while supporting technology development for adjacent markets and business growth; Build Global Technology Partnerships –Create/build partnerships globally/ across the company to accelerate technology integration and transition. Reduce risk and optimize our return on investment through effective scouting and key university, small business, and S&T customer relationships; Catalyze S&T Collaboration Opportunities - Focus on nanomaterial innovations through strong S&T Engagements, data analytics and information milestones to advance game changing technologies and support technology transition while sustainably growing our capability of today and tomorrow.