Materials Genome Initiative Leading to Economic Development of Alabama

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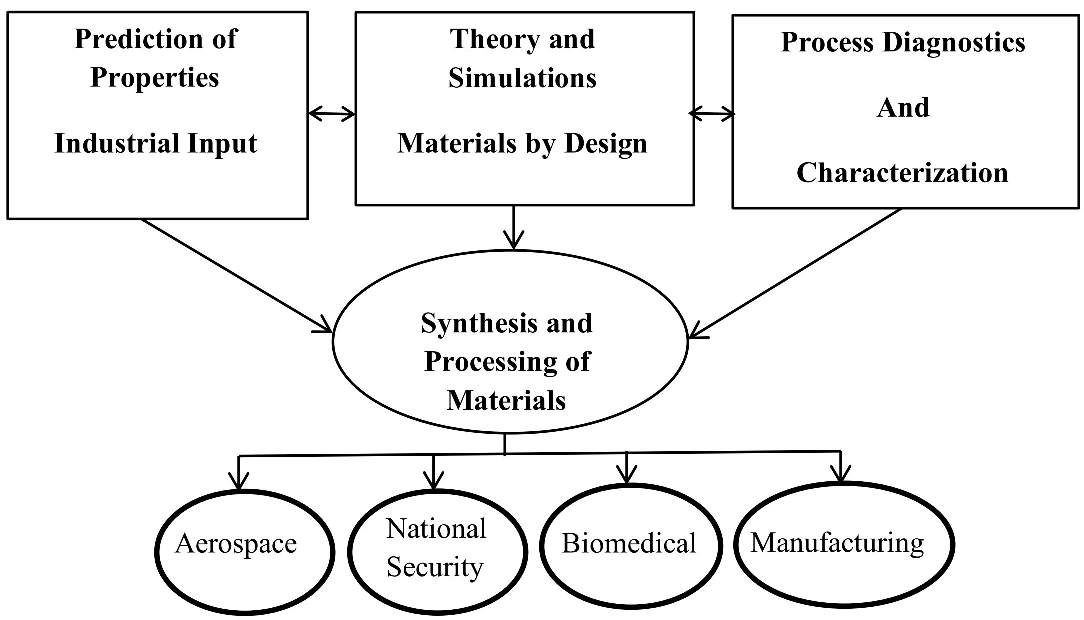
Problem to be addressed: The Materials Genome Initiative (MGI) at the federal level is a multi-agency initiative designed to create a new era of policy, resources, and infrastructure that support US institutions in the effort to discover, manufacture, and deploy advanced materials twice as fast, at a fraction of cost. Even though this MGI federal initiative has been in existence since 2011, its impact on Alabama has been minimal. With the new synergies as outlined in this Grand Challenge concept paper, Alabama is now poised to reap benefits of MGI with its manufacturing, aerospace, national security, and healthcare enterprise. *The reliability of computational approaches in predicting and designing materials combined with UAB's and Georgia Tech's expertise in materials synthesis and characterization, and existence of an innovation and entrepreneurship ecosystem has now created a new paradigm for achieving goals of MGI and launch new materials based industries in Alabama.* This combination will also transition the State of Alabama to the forefront of emerging quantum technologies and computation, which utilize devices that control, detect, and process information through mechanisms relying on increasingly novel materials and operational paradigms. New materials science concepts and organizing principles are needed for developing the necessary new materials and for validating the theoretical predictions that will allow us to take advantage of quantum phenomena.

Conceptual plan for the Implementation of MGI in Alabama



The focus will be on the following topical materials research areas

(1) Materials under Extreme Conditions for extreme environments in terms of pressure, temperature, corrosive and radiation environments for electric power generation, aerospace, manufacturing, and national nuclear security needs

(2) Biomaterials with a focus on wear-resistant materials for biomedical implants, materials for regenerative medicine and drug delivery. This would include both bio-stable and biodegradable materials including stimuli responsive polymers, minimally invasive gels, and nanomaterials

(3) <u>Materials for Sensors, Computing for Encrypted Communications</u> with a focus on optical sensors, quantum computing, and quantum communications
(4) <u>Materials far away from Equilibrium: Driven and Non-equilibrium Quantum Systems</u>

The demand for novel materials that respond in a desired way under extreme conditions or external stimuli is rapidly rising. Such advanced materials are necessary for a number of key technologies and industries such as national security and electric power generation. It has long been predicted that devices based on “quantum phenomena” will be the engine for future economic growth. Such new generation of devices will be able to store and manipulate information to provide radical new approaches for computing, communications, and sensing. Quantum phenomena are already being incorporated into technologies for next-generation computers, sensors, and detectors that demonstrate superior performance characteristics. Some of the novel quantum device capabilities currently envisioned include enhanced resolution in imaging, sensors, and detectors; advanced cryptography for more secure communication; and significantly larger computational capabilities at speeds far greater than those possible with present classical computing. Realizing these advances requires a detailed interdisciplinary understanding of how quantum materials behave far from equilibrium, accurate knowledge of how to integrate the components into complex systems, and precise control of the material structures. In this context, creating and controlling quantum states within materials is necessary for enabling next-generation technologies. Various aspects of quantum communication and quantum computing need to be developed, such as the computational science of developing and designing quantum algorithms, studying quantum programming languages and approaches to compiling programs, and developing applications of quantum computing using quantum programming languages. Our proposed activities will make UAB competitive to attract the future DoE, DoD, and NSF funding. For example, they directly address some of NSF’s Big Ten Ideas: Harnessing the Data Revolution; The Quantum Leap: Leading the next Quantum Revolution; Understanding the Rules of Life: Predicting Phenotype; and Midscale Research Infrastructure.

<u>Desired Outcomes in Materials Commercialization in Alabama</u>:

1) Utilizing our partnerships with Georgia Tech, DOE national laboratories and industry will enable access to the state-of-the art materials growth, characterization, and computational facilities for faculty, staff, and graduate students involved in this MGI initiative in Alabama. Novel materials and system prototypes can be built for commercialization thereby advancing the goals of the MGI in Alabama.
2) Implement NSF Innovation Corps (I-Corps^{TM}) curriculum to gain skills in entrepreneurship through training in customer discovery and guidance from established entrepreneurs. The I-Corps^{TM} program will be run in collaboration with the Materials Innovation and Learning Laboratory (MILL) at the Georgia Institute of Technology and Innovation depot in downtown Birmingham.

<u>Desired Outcomes in Human Resource Development</u>:

A well-prepared, innovative science, technology, engineering, and mathematics (STEM) workforce is crucial to the Alabama’s prosperity and security. Future generations of STEM professionals are a key sector of this workforce, especially in the four critical scientific areas identified under this MGI initiative. To accelerate progress in these areas, the next generation of STEM professionals will need to master new knowledge and skills, collaborate across disciplines, and shape the future of the human-technology interface in the workplace.

UAB Leadership Team:
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Collaboration with Georgia Tech:
David McDowell, Professor and Executive Director, Institute for Materials, Georgia Tech
Naresh Thadhani, Professor/Chair, School of Materials Science and Engineering, Georgia Tech

Collaboration with the Department of Energy National Laboratories:
1. Oak Ridge National Laboratory, Oak Ridge, Tennessee
2. Los Alamos National Laboratory, Los Alamos, New Mexico
3. Lawrence Livermore National Laboratory, Livermore, California
4. Argonne National Laboratory, Argonne, Illinois
5. Sandia National Laboratory, Albuquerque, New Mexico

Collaboration with the Alabama Companies:
1. Vista Engineering, Birmingham, AL
2. Evonik Corporation, Birmingham, AL
3. Southern Company, Birmingham, AL
4. DURECT Corporation, Birmingham, AL