## MGI Topic: Protecting and Improving Human Health

### **Challenge:** Point of Care Tissue-Mimetic Materials for Biomedical Devices and Implants

While biomaterials underlie a large proportion of medical breakthroughs, technologies, and devices, it is not yet possible to design and produce biomaterials tailored to a particular patient or clinical indication. Biomedical implants and wearable devices require materials that match the unique properties of the surrounding tissue. For example, current breast implant materials are inadequate due to property mismatch with the living tissues, uncontrolled leaching, and the need for invasive surgery. These complications can trigger immune response and body disfigurement, issues that also apply for other void-filling biomedical challenges, including volumetric muscle loss from battlefield injuries. An MGI approach, including data-driven design, can help address these constraints and enable quick development and fabrication of soft-tissue implants with customized properties and low immunogenicity. These advancements will then pave the way for computational design of biomaterials for more complex biomedical applications in the future.

## MGI Topic: Enhancing Structural Performance

### **Challenge:** Agile Manufacturing of Affordable Multi-Functional Composites

Thermoplastic composites offer a unique structural solution for loading in dynamic environments, where light-weighting, manufacturing process agility, and cost are critical drivers. A crucial application-space is in the transportation sector, from automobiles to aircraft and spacecraft. To date, adoption has been extremely limited due to performance uncertainties resulting from variabilities in materials and manufacturing processes. Most composites in use today were developed decades ago, using costly, iterative, highly empirical methods, which, in turn, makes modifying these materials to achieve new performance targets challenging. An MGI approach can address these challenges, yielding a step-change in the design and adoption of these game-changing materials. Key requirements include the development of digital materials design tools, processing to performance prediction models, and qualified materials data throughout the value-chain.

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## MGI Topic: Propelling the information and communications technology revolution sustainably

### **Challenge:** Materials Design for Sustainable Semiconductor Applications

The MGI community can help realize a future where artificial intelligence-powered autonomous experimentation (AI/AE) can accelerate the design and deployment of new materials that meet semiconductor industry targets, while also building in sustainability requirements from the outset. On October 30, 2024, the CHIPS R&D Program announced The CHIPS AI/AE for Rapid, Industry-informed Sustainable Semiconductor Materials and Processes (CARISSMA) funding opportunity[[1]](#footnote-1) to realize this challenge.

## MGI Topic: Advancing Critical and Emerging Technology

### **Challenge:** Quantum Position, Navigation, and Timing on a Chip

Position, navigation, and timing (PNT) is a pervasive need from vehicle navigation, logistics and supply chain tracking, precision agriculture, emergency response, augmented reality, to defense applications. However, virtually all PNT relies on the GPS infrastructure, which is both aging and easily disrupted, intentionally or by environmental factors. Development of a fully-integrated solid state quantum sensor—with integrated magnetometry, accelerometry or gyroscopy (position / navigation), and clocks (timing)—will enable robust autonomous navigation, unleashing a revolution in new technologies. Solid state quantum sensors are typically based on color centers or spin defects which are optimized for a single task such as field sensing, gyroscopic response, or timekeeping. These approaches are not necessarily amenable or optimized for coordinated, multi-factor sensing, and almost never assembled into a single host crystal. An MGI approach with multi-factor co-optimization of parameters will help accelerate the identification of target materials systems to facilitate the development of such an integrated sensor.

## MGI Topic: Enhancing structural performance & protecting the environment

### **Challenge:** High-Performance, Low-Carbon Cementitious Materials

High-performance materials are needed for structural applications, including in the rebuilding of areas ravaged by recent hurricanes. Furthermore, cement production is responsible for 8% of global CO2 emissions, mainly due to the high temperature calcination of calcium carbonate during production. Knowledge of the relationships between composition, reactivity, and long-term performance of cementitious materials were acquired, largely through trial and error over the past several centuries. To meet the urgency of low carbon, inexpensive, and higher performance cementitious materials will require an MGI approach. Efforts will need to connect understanding across time (from hydration and carbonation kinetics to long-term durability) and spatial scales (molecular scale dynamics to large scale structures). New tools that can link modeling and analytical approaches that support materials design are needed. The design of these novel materials will need to incorporate a set of performance requirements that are critical for widespread adoption, and include considerations of feedstock supply chains, workability, set times, aesthetics, and cost.

1. [Biden-Harris Administration Opens $100 million Competition to Accelerate R&D and AI Technologies for Sustainable Semiconductor Materials | NIST](https://www.nist.gov/news-events/news/2024/10/biden-harris-administration-opens-100-million-competition-accelerate-rd-and) [↑](#footnote-ref-1)