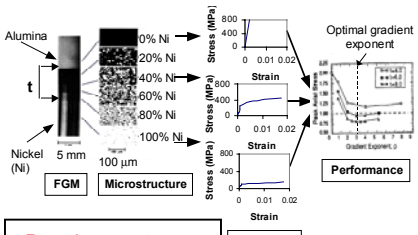
Functionally Graded Materials Development Laboratory

Design • Fabrication • Characterization • Modeling

Overview: The Functionally Graded Materials (FGM) Development Laboratory was created by Dr. Hugh A. Bruck, recipient of the ONR Young Investigator award, to both teach and advance the state of the art in integrating FGMs into the next generation of technologies being developed for a variety of commercial and military applications through a fundamental scientific understanding of FGM principles. The focus of the FGM Development Lab is to investigate FGM concepts for designing and fabricating materials and material systems that can adapt to our needs, whether it be to improve the way we travel, our personal safety, or the environment that we live in. To this end, the research activities of the FGM Development Laboratory are closely coupled with programs in a variety of centers at the University of Maryland dedicated to developing new energetic devices, rotorcraft structures, and smart structures.

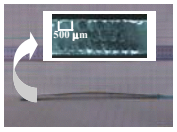
Concept: The basic concept behind the development of FGMs is to engineer gradual variations in material functionality throughout a structure to optimize

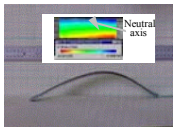


Development Concept for FGMs

performance. Recent advancements in materials fabrication processes are now making it possible to develop new technologies using FGM concepts that were previously relegated to the realm of our imagination.

Capabilities: FGMs are characterized both microstructurally and mechanically. Traditional metallographic equipment is used to prepare specimens for inspection using various microscopic techniques including optical, SEM, TEM, and SPM. Mechanical characterization is accomplished using traditional microhardness testing equipment and novel full-field characterization techniques such as Digital Image Correlation.





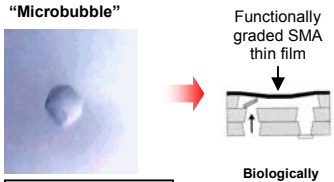
Microstructural and Mechanical Characterization of FGMs

Actuated deflection of functionally graded smart structure

Computational design and modeling is accomplished on Pentium III Workstations running under Windows NT and Linux platforms. A variety of graded materials can be processed from the nanoscale to the macroscale using a novel multi-stage molding technique, twin-screw extrusion, and DC magnetron sputtering.

Research: To facilitate the development of FGMs, fundamental scientific research is being conducted on the coupling of material and system behavior in graded architectures. Through a novel inverse design procedure, system performance is being optimized using model-based simulation of materials processing and performance combined with robust mathematical optimization techniques, such as Genetic Algorithms.

Applications: Numerous applications exist for FGMs. Some examples currently being investigated in the FGM Development Lab and elsewhere include: 1) metal-ceramic interfaces with reduced internal stresses and increased fracture toughness for joints and coatings; 2) smart structures with improved frequency response and shape control for flight control surfaces; 3) thin films exhibiting novel sensing and actuation behavior for MEMS; and 4) energetic materials with tailored performance for Mission Response Ordnance. We are continuously looking for new FGM applications, and would be happy to talk with you about your potential application.



FGMs for MEMS applications

Biologically Inspired concept for micropump

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