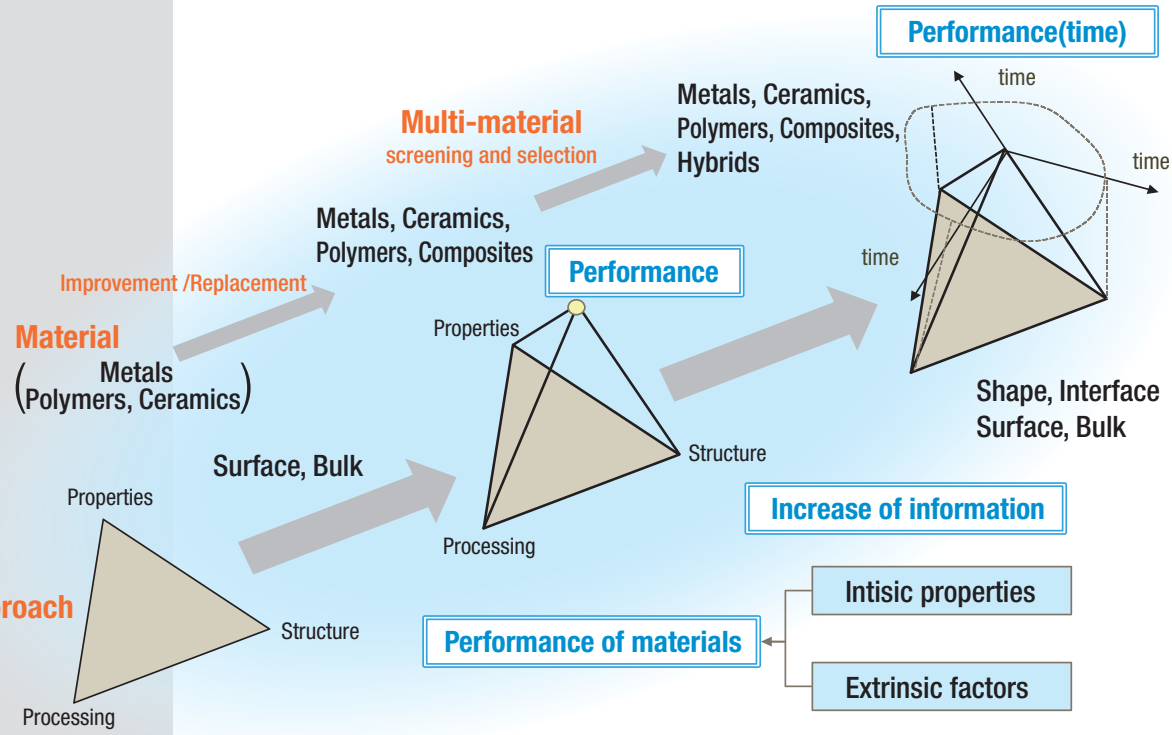
SIP-SM'41
Structural Materials for Innovation

MATERIALS INTEGRATION



Comprehensive material R&D support system to reduce R&D time

Materials Integration is defined as the integration of all scientific tools such as theory, experiment, analyses, simulation, database, etc. to solve real engineering problems during R&D processes of engineering materials. Target areas of the MI system are metals, polymers, ceramics, composites and hybrids, under actual service conditions. In particular, contribution to the understanding of time-dependent performance of engineering materials under service conditions is an important mission of MI.

Upper figure

Materials Integration in the SIP Innovative Structural Materials program is a mission to join processing, structures, and performance of engineering materials. The system also joins materials science and engineering from fundamental to application stages. The system is expected to apply to all kinds of materials: metals, polymers, ceramics, composites and hybrid."

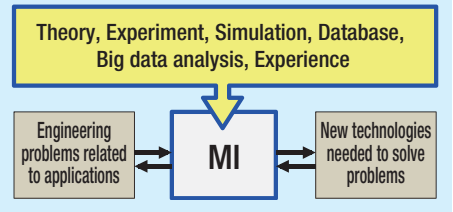
Lower right figure

The major purpose of Materials Integration is to combine all knowledge of materials science and engineering. The system is useful for both engineering and basic problems in related fields.

The major purpose of Materials Integration for structural materials is to create a new tool for reducing the time required for the research and development of materials and components. Through the MI tools, the relationship between materials, processing, structure and performance becomes easy to understand.

The understanding of this relationship at various levels is very effective for research and development. The relationship is applicable to all length and time scales. The MI system also enables inverse problems related to materials engineering. For example, the best microstructure of a material to achieve maximum performance is obtainable within a short time through the developed MI system. Thus, the system is very effective at understanding performance changes during long term applications. The system also provides information on the effect of service environment on the time dependent performance of materials and components. These computer-based estimations help to save research and development time.

In summary, the proposed Materials Integration system provides new integrated knowledge and the method to use that knowledge.



SIP-SM'4
Structural Materials for Innovation

The Characteristics of Materials Integration

Materials Integration systems developed in the SIP "Structural Materials for Innovation" program uses all the fields of science and technology related to materials, such as theoretical analysis, experimental approach, computer simulation, databases, big data analysis, computer-based informatics, etc. The developed system allows the solution to problems which are difficult to solve within the framework of the present approaches. The understanding of the relationship between, processing, structure, properties and performance is especially important for the basic design concept of the MI system.

Performance of Materials

The goal of the MI system is to understand the performance of materials and components. Important performances include fatigue, creep, corrosion, etc. These factors are all time dependent and the applications are based on long-term use conditions. This is a very important standpoint of the present MI system.

Time-saving and high efficiency

A full understanding of the change of performance with service time under service conditions is important. Without know-how and/or experience, the MI system enables reduction of research and development time, because the system can predict changes within a very short time. We do not need to do extensive experimental research and development.

Utilization of cutting edge science and technology

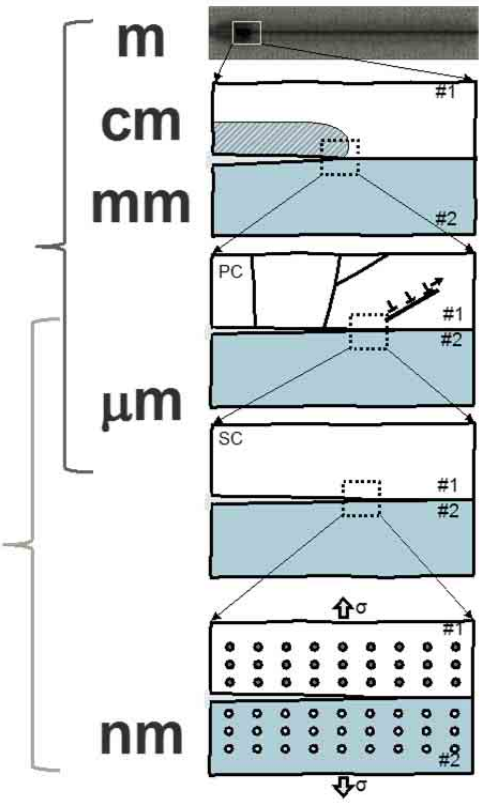
The MI system can make good use of new research at the forefront of science and technology. We can use both the new researches and the extensive research results of past research and development.

Application of Computer Science and Network

In addition to the currently used approaches in the field of materials science and engineering, new engineering approaches have used big-data analysis, databases, and their applications have been incorporated into the Materials Integration system.

Role of the MI and Future Trends

Problems related to the research and development of materials are solved using knowledge from various fields. In the future, the MI system has the potential to combine an IoT (Internet of Things) and AI (Artificial Intelligence), and is expected to become more effective tool for research and development of materials engineering-related fields. Materials Integration is expected to open new doors for new types of materials engineering tools.



Example of the Materials Integration Concept

Various kinds of length scale theories, simulation methods and experimental methods are available to understand mechanical properties of materials. In the interface decohesion model between ductile metals (or ductile polymers) and ceramics, the work of decohesion obtained from atomic level approaches is only 1/10~1/100 of that obtained in real bonded materials. To explain this difference, deformation of ductile metals in the range of μm~nm is especially important.

We need to understand that the best approaches vary with the dimensions involved. This best approach concept is especially important for the research and development of engineering materials. In particular, time dependent mechanical performance of materials is sensitive to the length and time scales of the approaches used. Consideration of the entire picture and use of adequate approaches are especially important for the understanding of mechanical behavior in multi-scale scenarios.

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