Position Paper: Some Aspects of Modeling Needs in Emerging New Technologies; MEMS, Photonics and Biotechnology

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There are several new emerging technologies and applications such as MEMS, photonics and biotech., biomedical sciences. For many of these new applications most of the emphasis has been on demonstrating feasibility, rather than on qualification, reliability and mass production. This is particularly true in the case of MEMS wherein very little work has been reported on the results of failure modes, failure rates and acceleration factors in stress testing. One of the key issues needed in order to accomplish that is physics based modeling of these devices and technologies. This document outlines some of the areas where progress is needed in the area of thermal, mechanical and reliability modeling for these new emerging fields.

Application	Needs by 2003 to 2005	comments
MEMS and Photonics	Modeling areas: Thermal, mechanical and reliability. New algorithms. A fundamental understanding of the basic principles that apply at the scale used in the particular application under consideration. Constitutive relations for the materials used in packaging will need to be developed. There will also be very stringent requirements on mechanical alignment for these applications. A very accurate methodology for modeling thermo mechanical displacements will be needed.	The normal laws of physics, chemistry, engineering and economics still apply but may need to be interpreted in different ways. New experimental techniques may also be needed to verify the modeling algorithms. Very accurate displacement measurements will be required. New failure modes and mechanisms will be need to be identified.

There is a need to integrate codes such that it would be possible to use the output from one code to generate a model in a different code. Typical examples would include:

a) Using data from a design code to generate a solid model (stress analysis, CFD etc…). The emphasis here would be to come up with a practical and way to translate the data. Although there have been many previous attempts at this they have generally failed to gain popularity because of 2 main reasons: (i) complexity of use because the data transferred had too much detail and needed to be modified by the user. A typical example is fillets that are very small scale that exist in the design output, and that would cause meshing problems. Users often complained it took them more time and effort to modify the design outputs than to create an entirely new model from scratch. (ii) Lack of reliability of the transfer process. Frequent errors with data transfers between codes have left users wondering if the effort and risk are worth it.

Biomedical and Biotechnology	Modeling areas: Thermal, mechanical and reliability. New materials will be used, that are compatible with the application under consideration. Many applications such as devices that are designed to be inserted in the patient will require materials that are compatible with safety and health. This will exclude many commonly used materials. There will also be application that include MEMS devices in them, and all of the considerations discussed in the MEMS section above will apply. Additional concerns will include operating temperatures, which will need to be close to the body temperature unless new and unique solutions are devised. Reliability requirements will be stringent and failure rates will need to be very well controlled.	New materials will require extensive experimental testing to determine constitutive relations for the materials. New failure modes and mechanisms will be need to be identified.

b) Using the output from one code as input (initial and boundary conditions) in another code. Typical examples here would include using a CFD code to generate a thermal set of initial and boundary conditions for a stress analysis code. The essential needs here are to be able to transmit data from one code to another. This can occur at varying levels of complexity. In the simplest case one would run an analysis (CFD) to generate a temperature distribution in steady state, then be able to export this temperature distribution to a different code such as ANSYS or ABAQUS and be able to use the temperature distribution as an initial or boundary condition for the mechanical analysis. A more complicated problem would be one where the thermal and mechanical problems are coupled. In that case as one completes the thermal analysis, the data would be exported to the mechanical analysis, then the mechanical analysis output would be sent back to the CFD code, and so on. This would arise for example in a damaged thermal interface. Under such conditions the temperature distribution affects the interfacial gap which in turn effects the temperature distribution.

Of course it is possible to try and eliminate many of the above difficulties by creating codes that combine multi-physical phenomena. This has been done in the past with varying degrees of success. A particular area of interest is combining thermal and mechanical analyses, since many design and reliability issues require a thermo mechanical analysis. This is currently possible for simple problems such and conduction heat transfer combined to a stress analysis. However when one considers convection, laminar or turbulent, radiation, mass transfer, and chemical reactions, it becomes obvious that different codes for different phenomena will be with us for a long time.