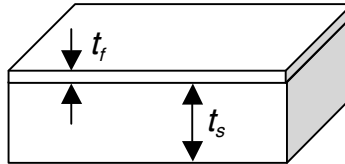


Department of Aeronautics & Astronautics
MIT
Field Exam, Jan. 2010
Question – Materials & Structures

Students should choose either **(A)** or **(B)** to answer (structures and materials focus, respectively).



The sketch above represents a film barrier coating perfectly joined to the surface of a planar substrate, having thicknesses t_f and t_s , respectively. Both materials are isotropic.

(A) The structure will be heated to elevated temperature ΔT , and it is of interest to analyze failure of the structure. Develop analyses as detailed below to determine the appropriate quantities useful in assessing failure. The panel is very large in the planar directions and boundary condition effects may be assumed negligible here.

(A.1) For the case $t_f \ll t_s$, solve for the relevant quantities to assess simple failure.

(A.2) For the same case where $t_f \ll t_s$, calculate the strain energy in the film. Evaluating the strain energy is a component of assessing decohesion of the film layer from the substrate.

(A.3) Consider the case where $t_f \sim t_s$, and setup the governing equations similar to (A.1), but do not solve.

(B) The film/substrate combination given above needs to be improved with regard to failure. An extensive program has been designed to explore improvements to the film barrier, focusing on changing processing parameters in forming the film. Films in all cases are ~ 1 micron thick or less, and the films are oxides on a metal alloy.

(B.1) Discuss the types of characterizations available to assess characteristics of the different films as processing is varied. Discuss what characteristics you would be interested in, and how they might be best assessed.

(B.2) The film/substrate structure will be subjected to a temperature change ΔT during operation. Discuss mechanical properties relevant to assessing failure, and how those might be assessed in simple experiments.

(B.3) Many films on substrates are formed naturally at standard atmospheric conditions (STP) on the earth, such as oxides on Si and Al. For many engineering applications, the oxides are ignored. Discuss general features of such film/substrate systems and the characteristics (chemical, material, mechanical, etc.) that allow the films to be ignored in analyzing the structure. Generalizing from an example film/substrate you are familiar with may be helpful.