The energy based approach to Fatigue

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Résumé

The author has been working in the energy based models in Fatigue over the past 30 years. This paper is a review of this approach.
In the case of fatigue crack initiation, initial models based on dislocation kinetics are reviewed. As a recent application, the models developed in the microelectronics applications are presented.
In the case of fatigue propagation, recent developments of the model developed by the author are highlighted. It is shown that most effects attributed to crack closure can be successfully described based on Energy concepts. It is proposed that two fundamental modes of crack growth exist
- one based on cycle by cycle crack growth by striation formation at moderated growth rates,
- second based on a step by step growth at low growth rates.
Based on these facts, a unique crack growth model is proposed that permits the description of fatigue crack growth covering 7 decades, irrespective of the environment.
In the case of variable amplitude loading, the energy based analysis shows a similar evolution , based on the existence of two modes of crack growth.
The model is extended to fatigue of elastomers – where it is shown that hysteretic energy describes the effects of frequency and the load ratio.
A viscoelastic model is developed and it can be shown that specific aspects of elastomer fatigue, such as the strain induced crystallization can be described by energy concepts.
Finally multi-axial fatigue behavior in an elastomer is successfully described based on the energy model.