Multi-Physics Multi-Scale Model to Predict Corrosion Behavior of Dissimilar Material Joints

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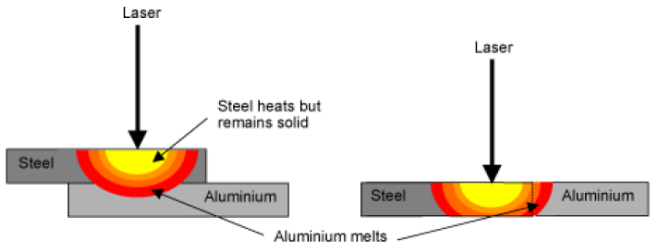
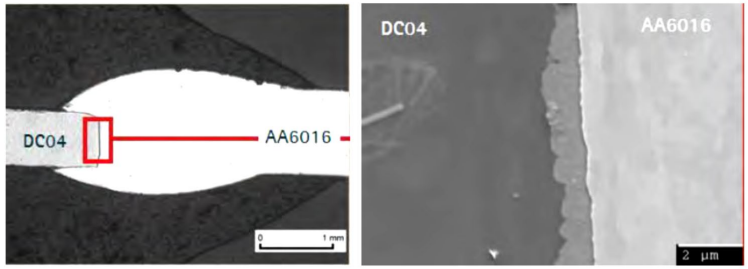
Objectives: Main objective is to develop a multi-physics and multi-scale computational model for predicting corrosion and resulting impact on the mechanical behavior of dissimilar material joints under typical vehicle environments

Technical Approach: The proposed model will incorporate the effects of joining-process parameters on the microstructure and stress-state of the dissimilar materials involved. The model will incorporate different types/modes of possible corrosion mechanisms including galvanic corrosion, pitting corrosion, crevice corrosion, stress corrosion cracking, and resulting corrosion fatigue, based on the dissimilar materials involved, joining process, joint geometry, and the environmental parameters.
The proposed model will be built around a multi-physics multi-scale platform. The corrosion behavior, especially the galvanic effects of dissimilar materials can be modeled by solving for the 3D distribution of local potential and current density distribution around the joint. The model will predict different modes of corrosion (e.g. pitting) on the anodic material in the galvanic couple under a given environmental condition. Experimentally determined kinetic parameters will be used to calculate the rate of degradation and predict rate of degradation (lost thickness, pitting, or crack propagation) and its effect on the mechanical behavior of materials. This model should predict the resulting strength or the fatigue life of a joint by utilizing continuum models and fracture mechanics approach.

Concept Illustration:



Schematic of the laser joining process for both lap and butt joints



Laser welded aluminium/steel butt joint

Impact: A number of new automobiles are designed using a variety of dissimilar metallic alloys where these materials may be joined or welded together. Synergistic effect of corrosion and mechanical forces can cause a premature failure of these structures. The proposed approach to develop a model will have broad applications in a variety of industries and be capable predicting behavior for any combination of conducting dissimilar materials in a given environment.