

COMPUTATIONAL MODELING OF WELDING AND PROCESSING TECHNOLOGIES

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ABSTRACT

The invited session on Numerical Modeling of Welding and Processing focuses on advances in computational approaches for understanding, predicting, and optimizing welding and joining operations. Numerical modeling has become essential in welding research and engineering, improving process efficiency, joint quality, and reducing experimental effort. By simulating heat transfer, process parameters, and material behavior, these models provide insight into weld pool evolution, phase transformations, residual stresses, and resulting properties.

Welding involves complex coupled phenomena, including melting and solidification, fluid flow, heat and mass transport, microstructural evolution, and stress development. These require multiphysics and multiscale modeling using methods such as finite element, finite volume, smoothed particle hydrodynamics, Monte Carlo, and phase-field techniques, enabling prediction from macro-scale thermal fields to micro-scale defects.

The session covers fusion and solid-state welding (e.g., friction stir and friction deposition), brazing, soldering, adhesive, and mechanical joining. Contributions on both fundamental modeling and industrial applications are welcome, along with emerging AI, machine learning, and digital twin approaches for optimization, monitoring, and control. Emphasis is also placed on joining advanced and dissimilar materials such as lightweight alloys, polymers, and composites. Topics of interest include:

- Heat source characterization and modeling
- Weld pool dynamics and transport phenomena
- Phase transformations and microstructure evolution
- Constitutive behavior and friction modeling
- Defect prediction and mitigation (porosity, cracking, distortion)
- Sensing, control, and automation in welding processes
- AI/ML and digital twin approaches for optimization and monitoring
- Joining of advanced and dissimilar materials