

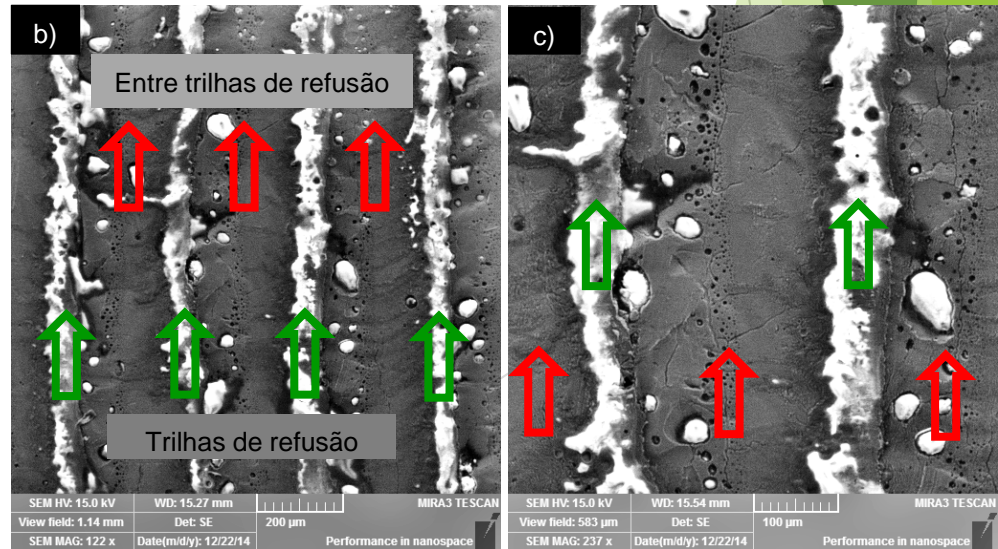
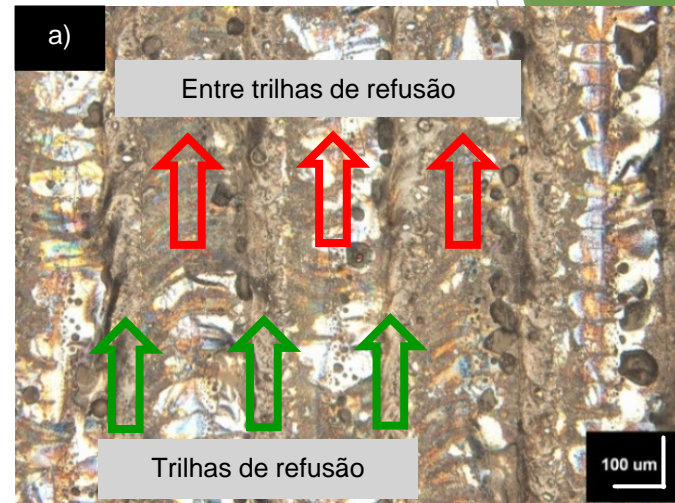
GEOMETRIC MULTIGRID SOLVER AND EXPERIMENTAL VALIDATION IN LASER SURFACE REMELTING

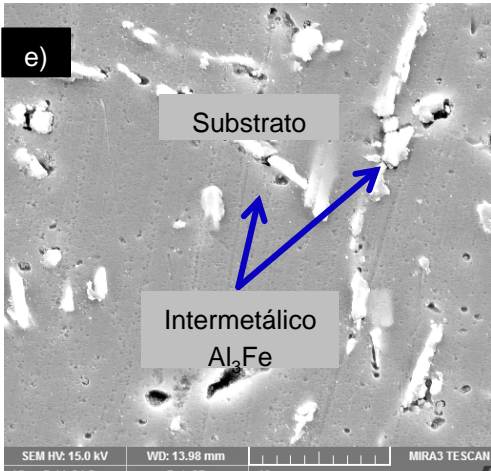
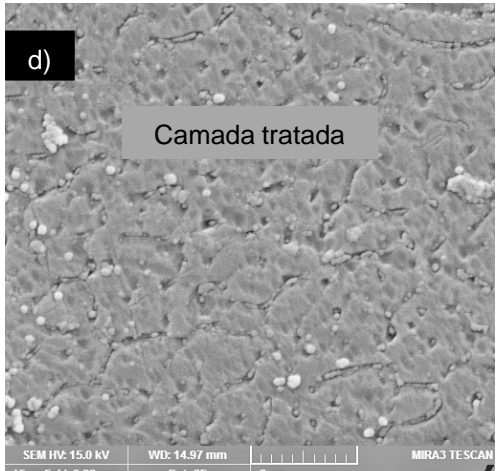
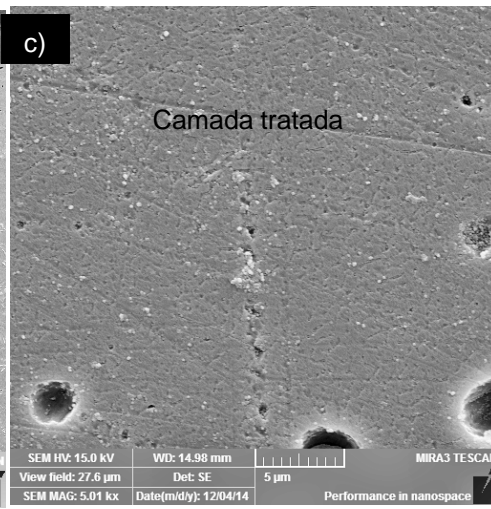
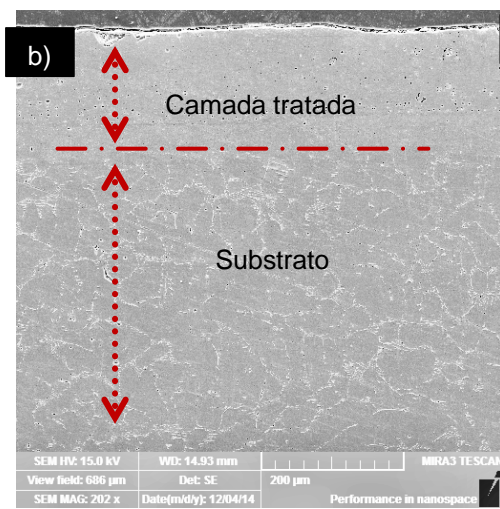
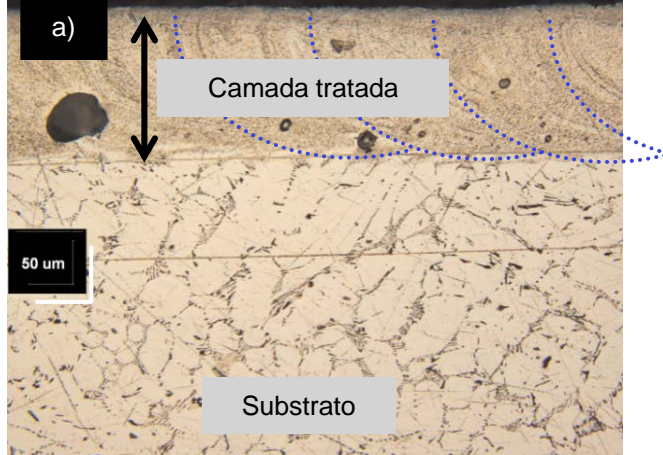
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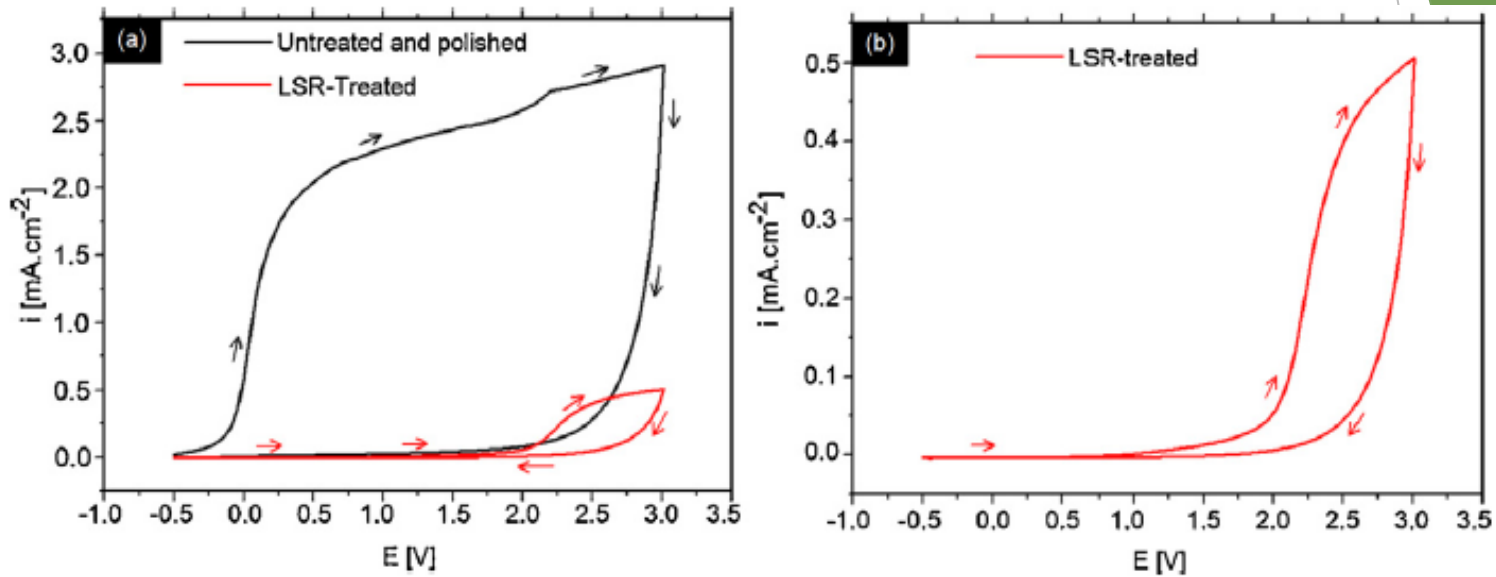
INTRODUCTION

Al-1.5 wt.% Fe alloy was irradiate by Yb-fiber laser beam using the laser surface remelting (LSR) technique



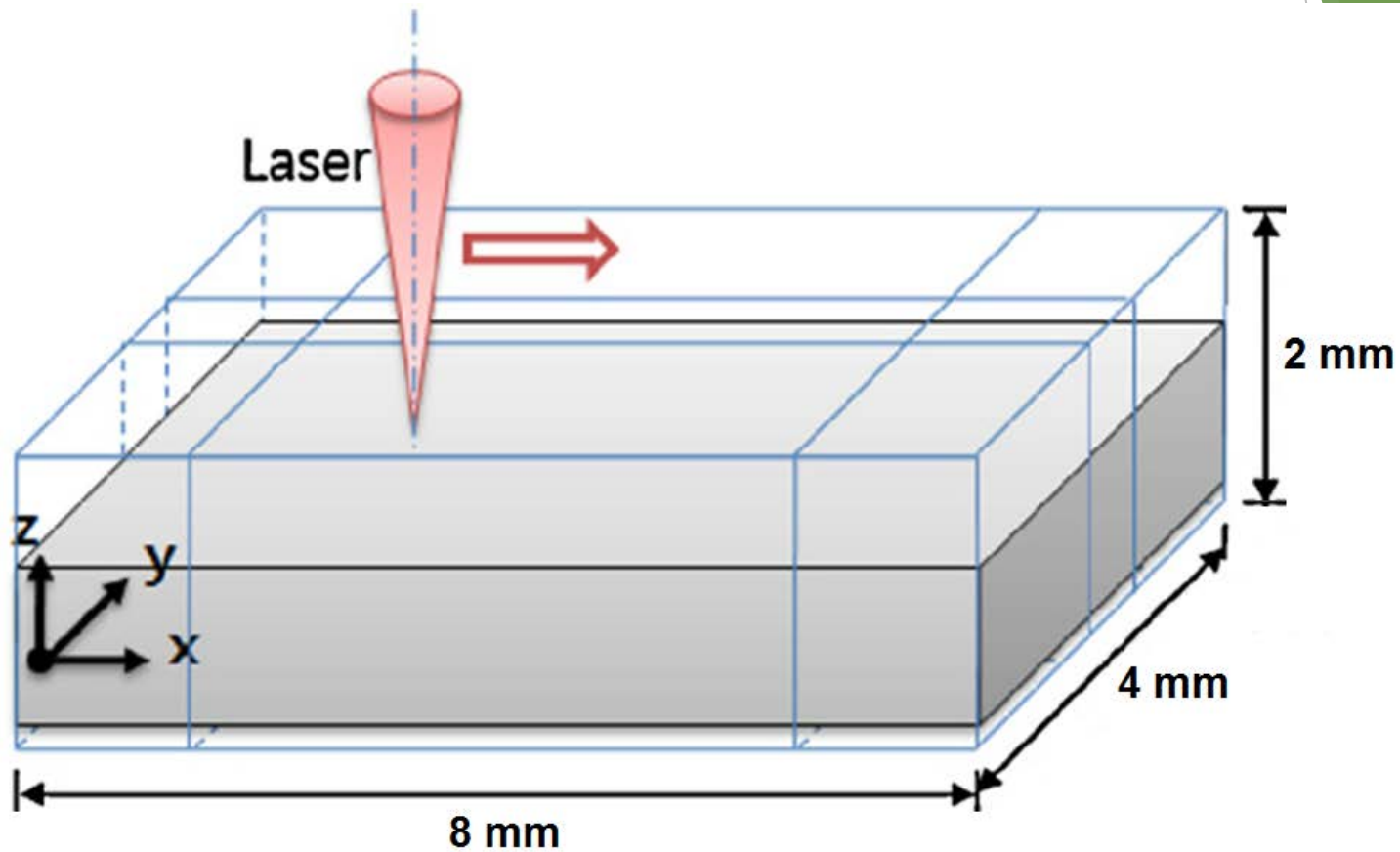


The laser-treatment showed to be an efficient technology for corrosion resistance improvements

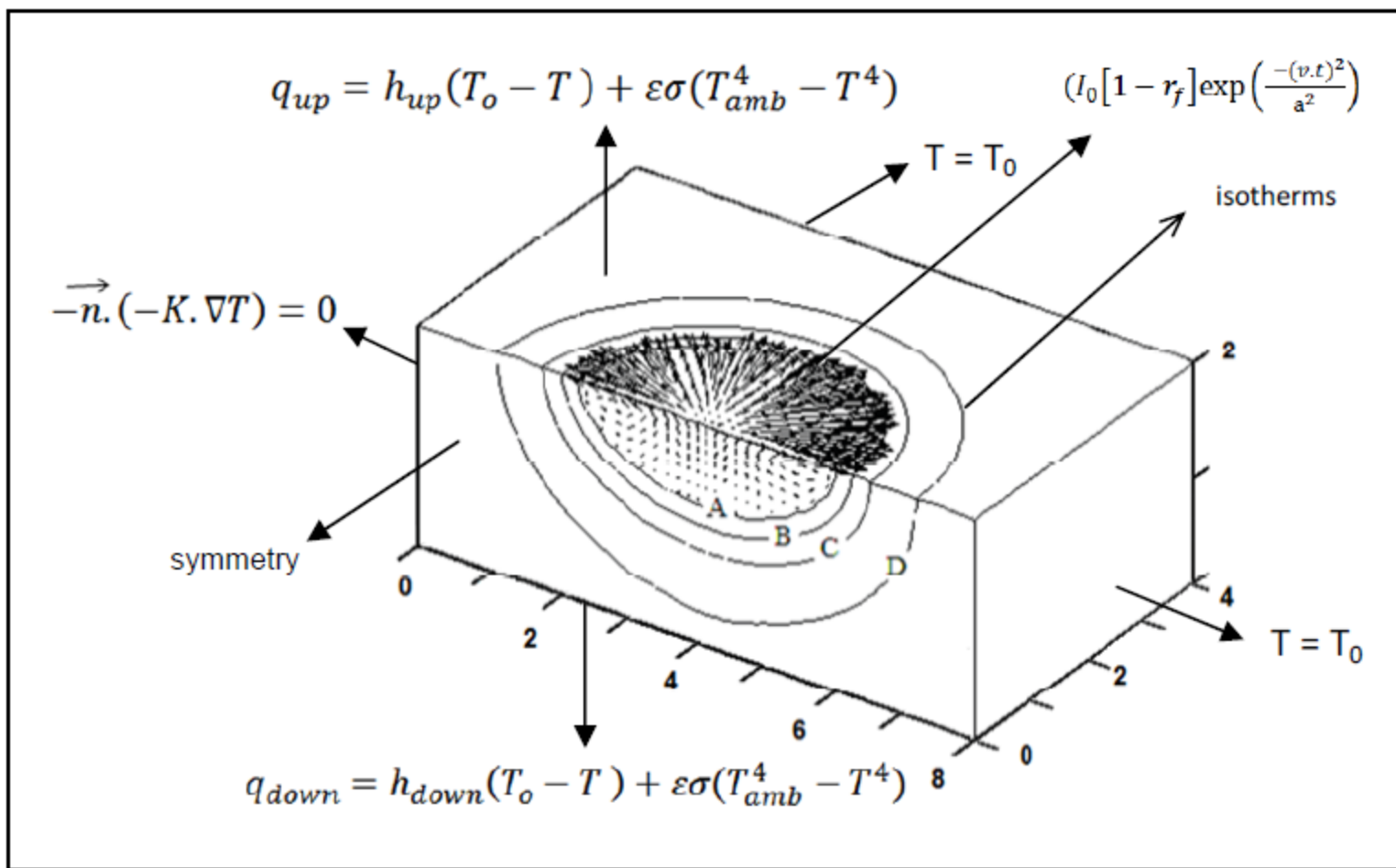


Cyclic polarization curves (a) untreated and laser-treated specimens and (b) magnification for the laser-treated specimen.

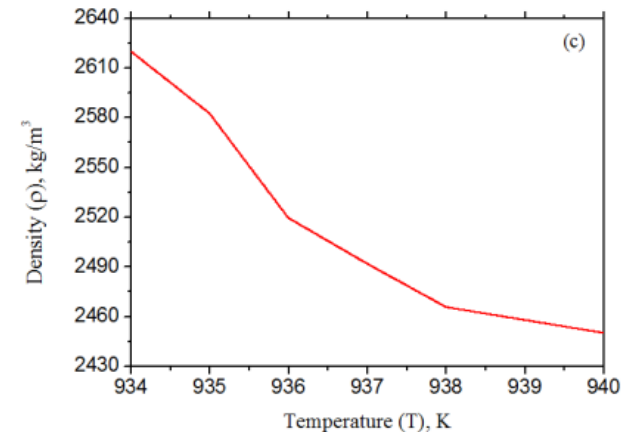
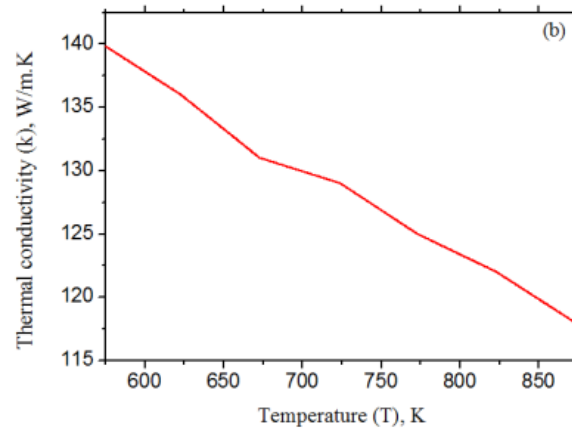
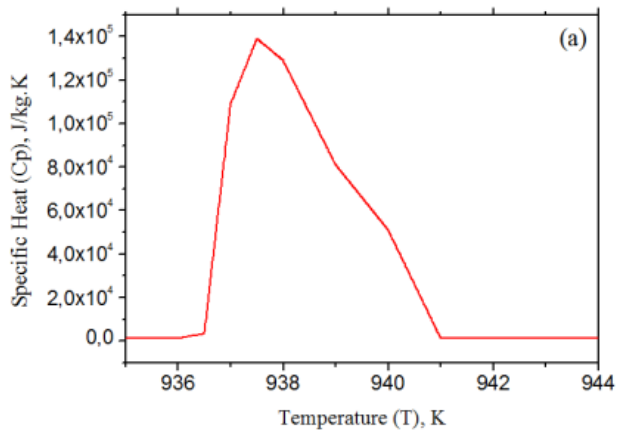
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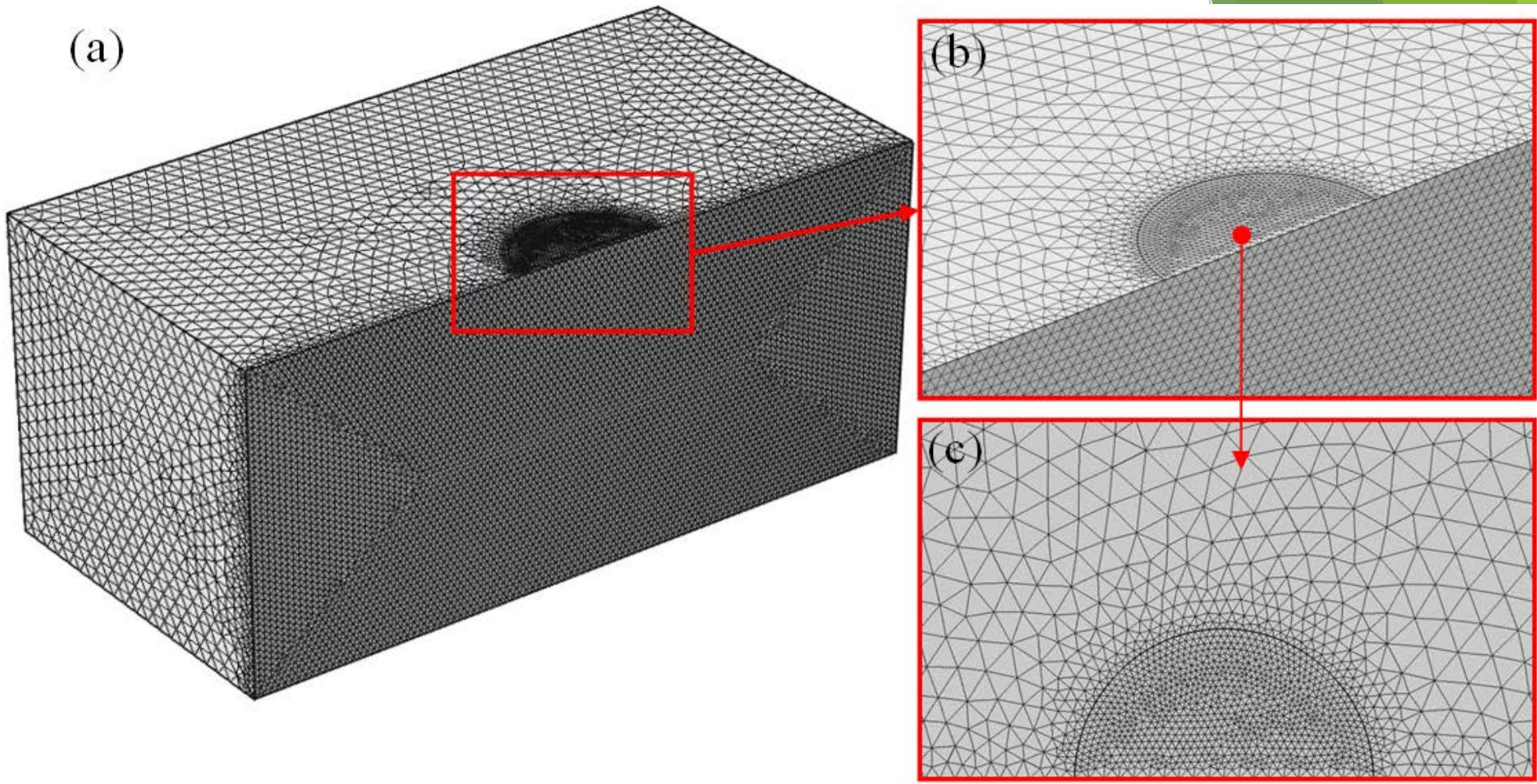
Schematic view of the laser welding simulation



A 3D computational view of the temperature distribution, including isotherms, for the laser-melted zone, where the initial and boundary conditions are indicated



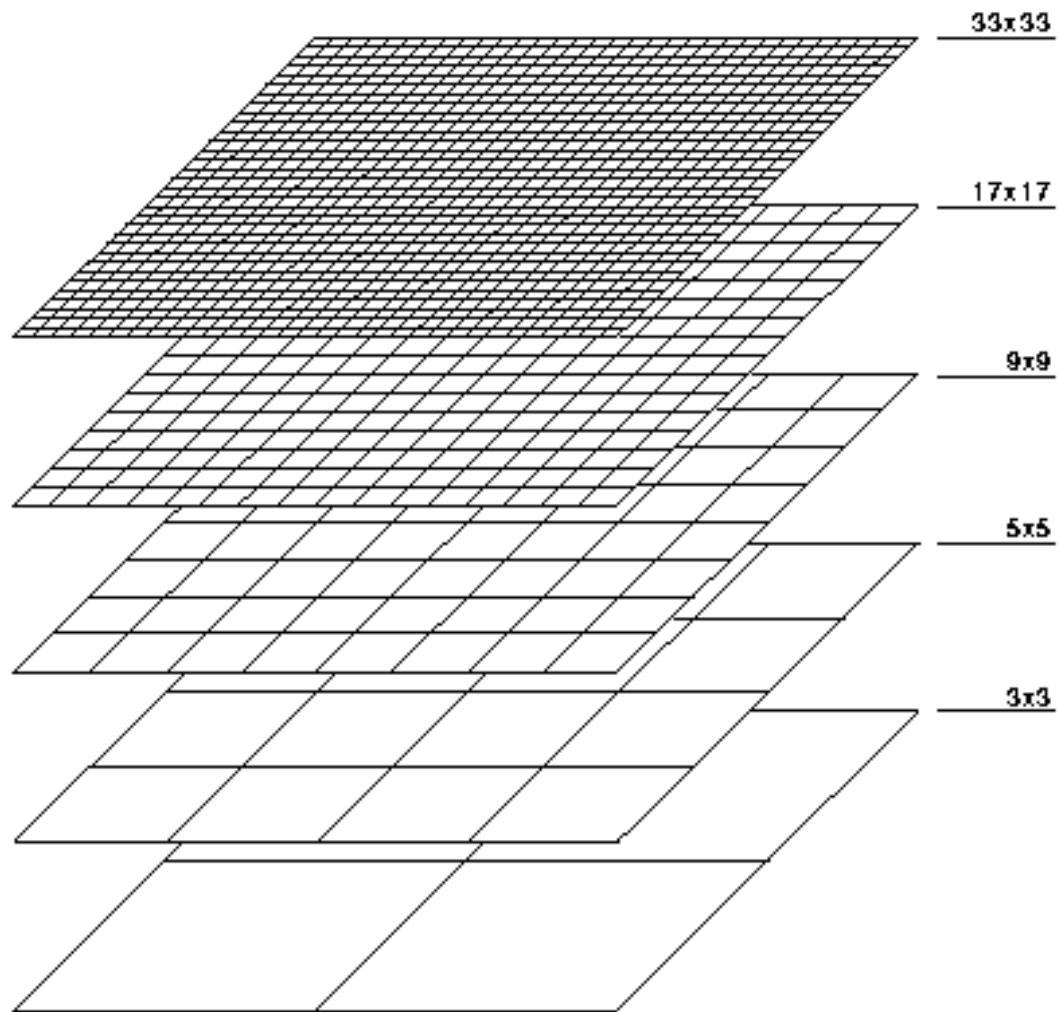
Thermophysical properties of Al-1.5 wt.% Fe alloy: (a) specific heat C_p , (b) thermal conductivity k , and (c) density ρ (Thermo-Calc software).



The mesh and its refinement used in this work: (a) tridimensional view, (b) magnification of details and (c) a top view

MULTIGRID METHOD

- Technique very promising of optimization that reduced drastically the CPU time
- One of the most used numerical methods in the solution of systems of equations
- This method consists on the transference of information among a refined grid, in which the numerical solution is desired, and coarse auxiliary grids,
- The transference of information between two meshes is done by operators: restriction (from a finer to a coarser grid) and prolongation (from a coarser to a finer grid), following a predetermined sequence of meshes.
- The methods to solve system of equations in a unique mesh are called Singlegrid (SG).
- Multigrid methods show that the choices of parameters (algebraic or geometric Multigrid, the coarse mesh structure, solver, inner iterations in each mesh, cycles, restriction and prolongation operators, coarsening rate and others) can have a strong influence in the efficiency of the algorithm.
- There are no general rules in the choice of these parameters
- The convergence rate depends on the parameters choices

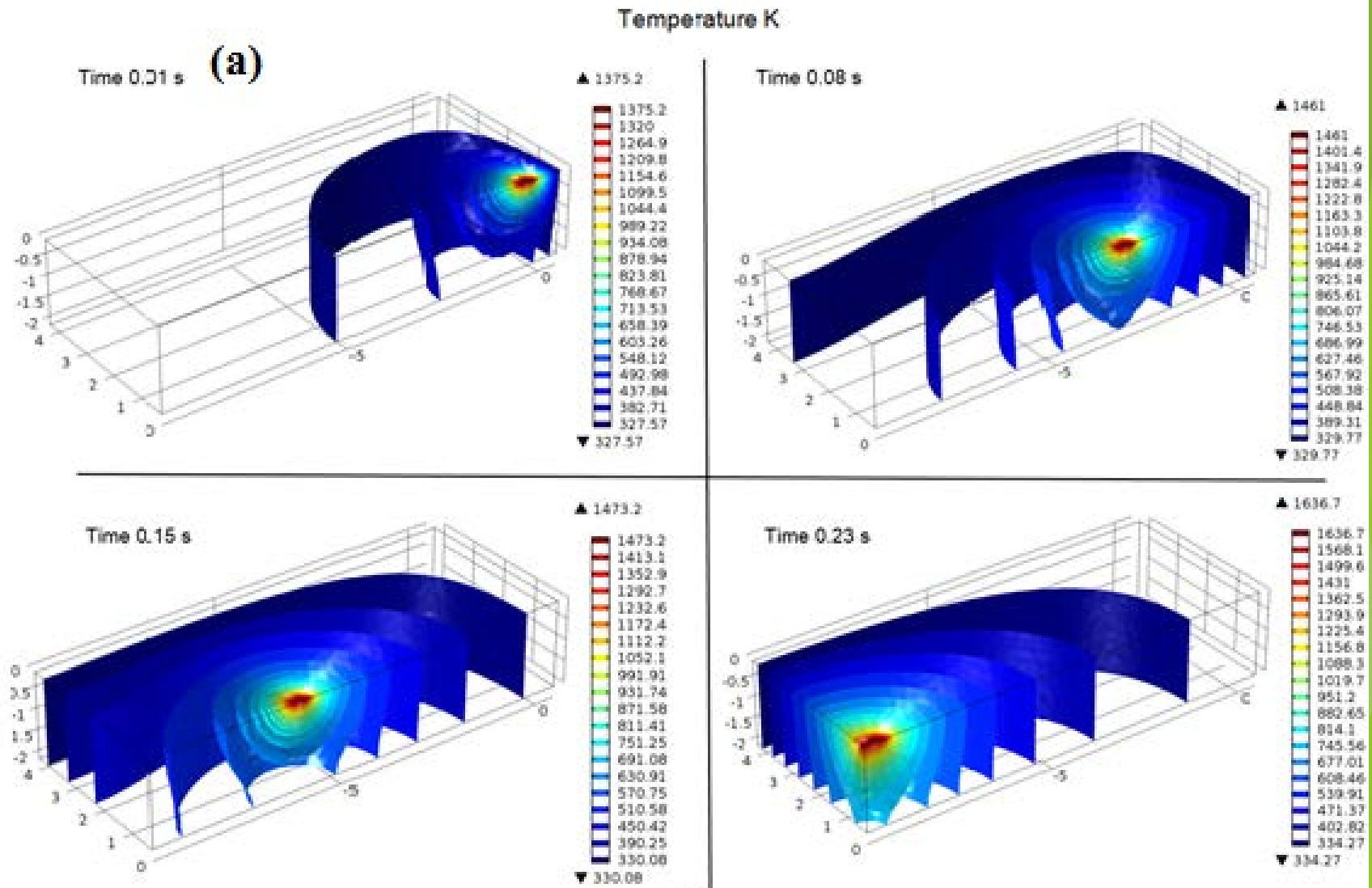


Process of mesh coarsening and generation

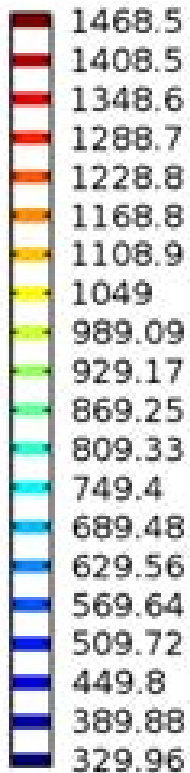
Objective

- In this study, the finite element method was used to simulate the solidification processes by LSR technique.
- In this study we analyzed the influence of different geometric Multigrid parameters on the CPU time in the numerical simulation problem.
- To validate the result of numerical simulation with the experimental result was done the microstructural characterization of laser-treated layer by the optical microscopy and SEM techniques and however, that both results showing be consistent.

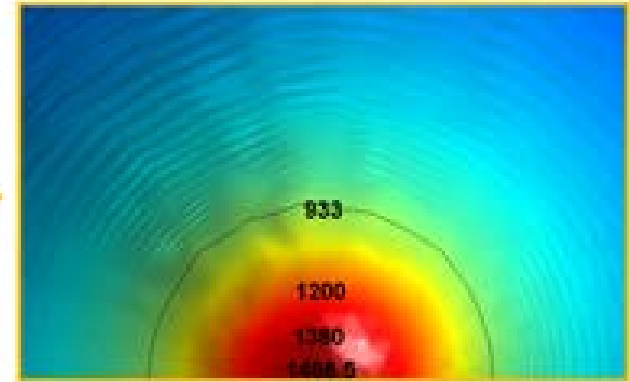
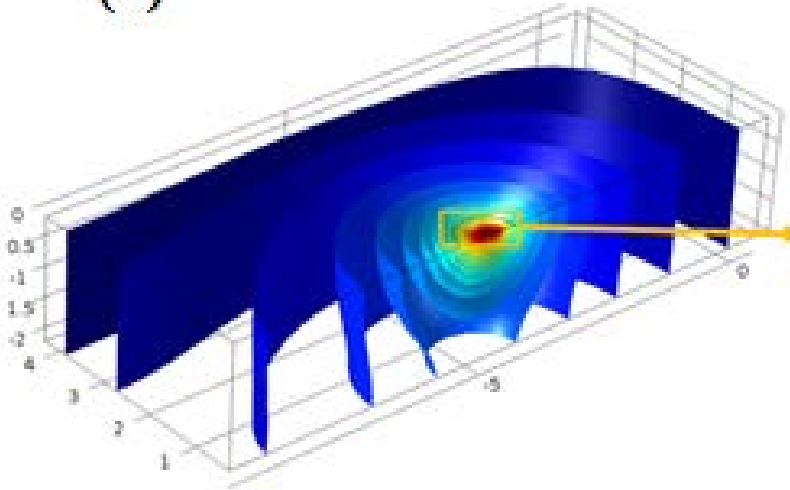
RESULTS AND DISCUSSIONS



▲ 1468.5

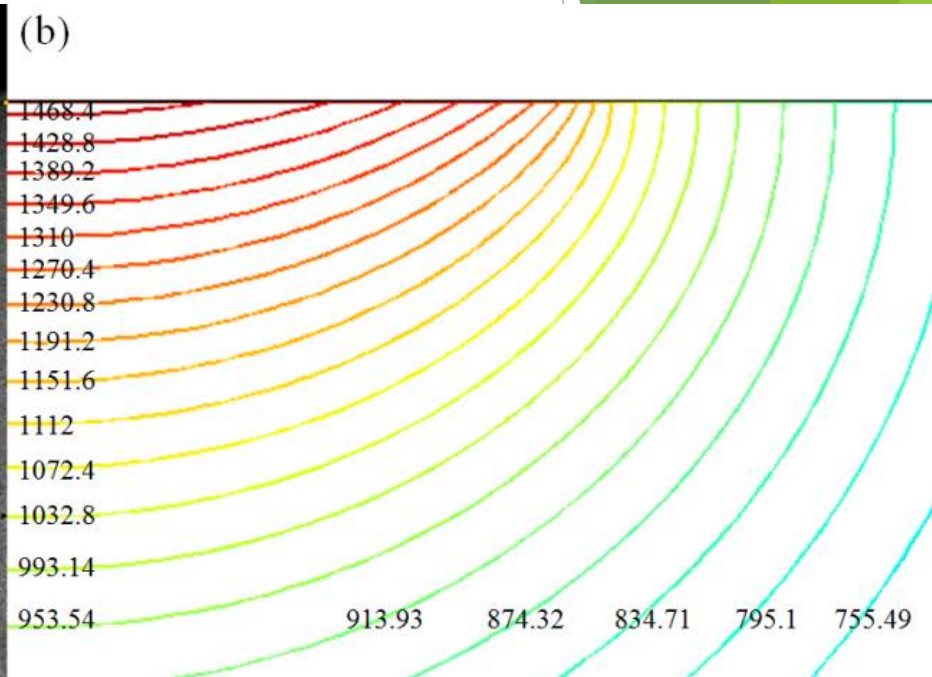
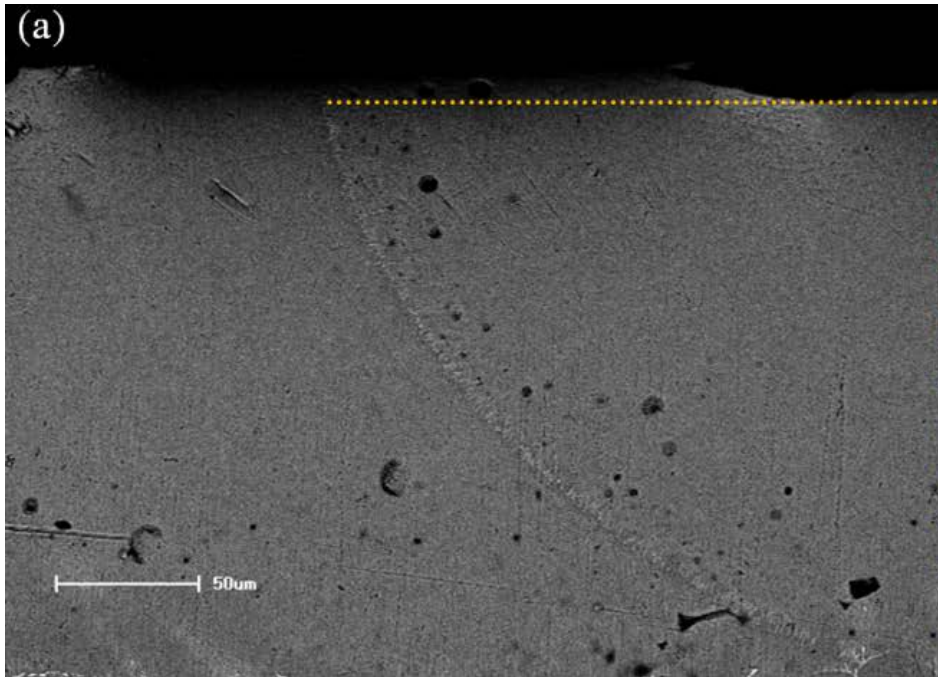


(b)



▼ 329.96

Numerical simulation during the solidification, showing the pattern of the distribution of the isotherms formed by the LSR treatment: (a) Distribution of the isotherms in mode transient in different instants of time and (b) magnified view of the LMZ for the instant of 0.15 s.



Comparison between the experimental sample and the numerical simulation, both in the cross section view, where: (a) is a SEM micrograph and (b) is the simulation result.

CONCLUSIONS

- **In the cross-section was observed the cast zone with homogeneous behavior of microstructure and with the presence of many nano porosities.**
- **This characteristic of microstructure of the laser-treated sample greatly improves the resistance to corrosion as was shown.**
- **A transient three dimensional heat transfer problem of the laser remelting process was performed by a numerical simulation with the use of the Finite Element Method (FEM), which allowed the prediction of the temperature distributions in the weld fillet.**
- **The CPU time was reduced through the use of Multigrid method (MG) to solve that problem.**
- **A transient problem in 3D with thermophysical property variables was applied Multigrid technique for simulated, since the execution time fall of approximately 6 hours to 20 minutes.**
- **Multigrid method is a technique very promising of optimization that reduced drastically the CPU time**