Optically Pumped Micromechanical Oscillators

MATH0471 – Spring 2021

---

v1 (02/02/2021)

This project consists in studying the multiphysic problem of micromechanical oscillators excited with pulsed laser beams. The underlying coupled thermomechanical problem will be discretized using a three-dimensional finite element method. The numerical scheme will first be developed, tested and validated for the solution of the uncoupled thermal and elastic equations. Then, loosely or tightly coupled solution strategies will be investigated. The code will be applied to several geometrical configurations, from a simple beam to more sophisticated oscillator shapes.

The project is organized as follows:

1. Students will be divided in 2 groups. Each group will write its own solver.
2. Three intermediate deadlines are given, with a mandatory (but not graded) 8-page progress report that should detail the computer implementation and the mathematical, numerical and physical experiments.
3. The final report (about 60 pages) will present the method and numerical results, the computer implementation and a detailed analysis of physical experiments on non-trivial configurations.
4. An oral presentation of the main project results will be organized during the June exam session; individual theoretical and practical questions will be asked to each member of the 2 student groups.

Important dates:

1. **Wednesday March 3rd: Intermediate deadline #1 (Finite element method for the transient thermal problem)**. Implementation of the three-dimensional finite element method using Lagrange shape functions of arbitrary order for the thermal equation with Dirichlet and Neumann boundary conditions, discretized in time using the implicit Euler method. The implementation should take advantage of the Gmsh library for creating and/or reading the mesh, computing values of shape functions and Jacobians, as well as exporting results; and the Eigen library for numerical linear algebra. The code should be validated (convergence) on a simple beam (a 3D parallelepiped).

2. **Wednesday March 31st: Intermediate deadline #2 (Finite element method for the transient isothermal elastic problem)**. Extension of the thermal code to handle elasticity with homogeneous Dirichlet conditions. The time discretization should be performed using a Newmark scheme, and the code validated (convergence and stability) on the same simple beam geometry.

3. **Wednesday April 28th: Intermediate deadline #3 (Extension to coupled problems)**. Extension of the thermal and mechanical codes to solve the coupled thermoelastic problem, using either a loosely (one-way, staggered) or a tightly (strong) coupled approach, with either a monolithic or an partitioned (iterative) algorithm.

4. **Wednesday May 12th: Final deadline**. Final report and code, with tests and analysis of physical results on more sophisticated oscillator geometries.

5. **June session: Exam**. Oral presentation of the projects.

The full source code should be tagged in the ULiège GitLab for each deadline, and should be directly configurable and compilable on the CECI clusters. The reports in PDF format should also be associated to this tag on GitLab for each deadline.