

Heat Transfer and Phase Transformation on Matrix Assisted Pulsed Laser Evaporation (MAPLE) of Biocompatible Thin Layers

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Abstract

Introduction

The Matrix Assisted Pulsed Laser Evaporation (MAPLE) process is used for high quality biocompatible polymers thin films deposition, such as PVP (polyvinylpyrrolidone) and DMSO (dimethyl sulfoxide).

To maintain the high quality of the sample during the entire process, the laser targets temperature should be kept below 70 K, while controlled evaporation occurs under the action of high energy laser pulses.

On a first approach, COMSOL Multiphysics® is used to describe and analyze the current cooling technology (fig 1a, b), in order to identify the present bottlenecks of the process.

Use of COMSOL Multiphysics®

Based on the analysis results and process characteristics a new path of energy dissipation is designed and modelled. The SolidWorks® model is exported through the LiveLink™ for SolidWorks® add-on in COMSOL Multiphysics® where heat transfer and phase transformation analyses are performed (fig. 2).

Each phase of the process was properly described and designed with the use of 3D/2D plot groups and line graph tools in COMSOL Multiphysics®. The step by step analysis was done using a time dependent study with a time span of 90 minutes on an increment of 2 minutes.

In order to simulate accurate conditions, the COMSOL Multiphysics® material data base was used and customized with new materials.

Results

Biocompatible materials need to be cooled to lower temperatures in order to survive unharmed during laser evaporation, actually a laser sublimation process. The designed cryocooler (fig. 3, 4) with the support of analytic and modeling facilities of COMSOL Multiphysics®, answers very well to the Pulsed Tube Refrigeration (PTR) technology requirements, allowing better

cooling and temperature stability throughout the MAPLE process than current liquid Nitrogen solution.

Conclusion

By the use of COMSOL Multiphysics®, a proper analysis of the sublimation phenomenon of biocompatible substances was performed, making possible designing adequate re-engineering solutions of deposition equipment.

This has an effect on the availability of new ways to integrate biocompatible films in all sorts of medical, technological and dual applications.

Reference

1. Chrisey D.B., Hubler G.K., Pulsed Laser Deposition of Thin Films (1994)
2. Sadoqi M., Kumar S., Yamada Y., J. Thermophys. Heat Transf. 16, 193 (2002)
3. Piqué A., McGill R.A., Chrisey D.B., Leonhardt D., Mslina T.E., Spargo B.J., Callahan J.H., Vachet R.W., Chung R., Bucaro M.A., Thin Solid Films 355/356, 536 (1999)
4. Pate R., Lantz K.R., Stiff-Roberts A.D., Thin Solid Films 517,6798 (2009)
5. Wu P.K., Ringeisen B.R. et al Thin Solid Films 398–399, 607 (2001)

Figures used in the abstract

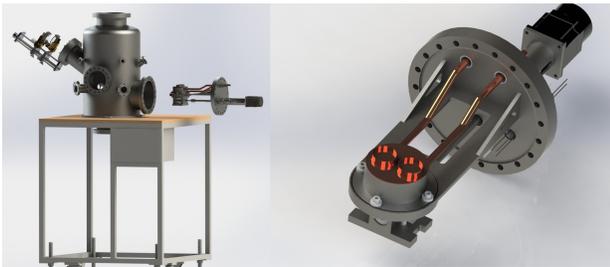


Figure 1

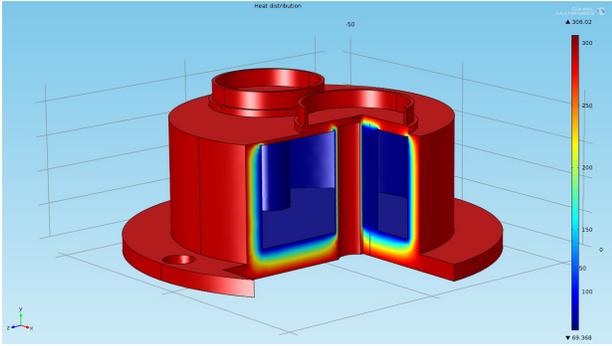


Figure 2

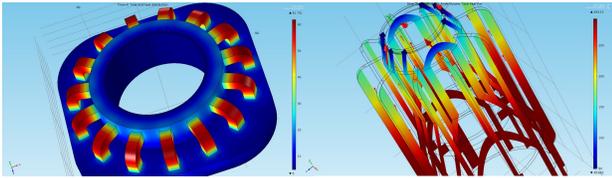


Figure 3



Figure 4