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

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Introduction:

Matrix Assisted Pulsed Laser Evaporation (MAPLE) technique is used for the deposition of high quality biocompatible polymer thin films (Fig.1,2)

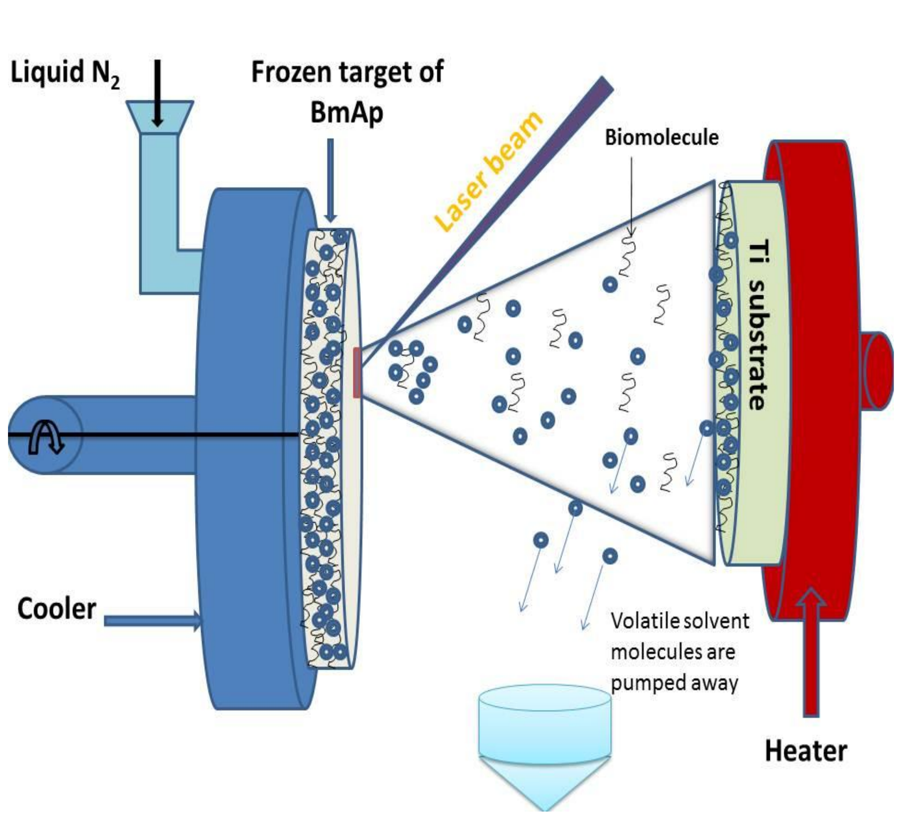

Figure 1. MAPLE technique

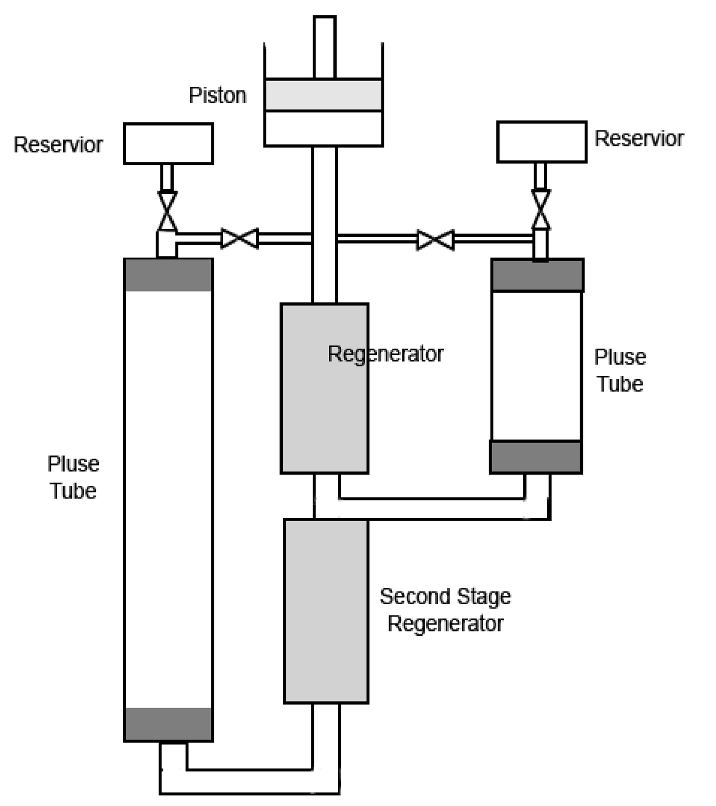

Figure 2. Multi stage PTR

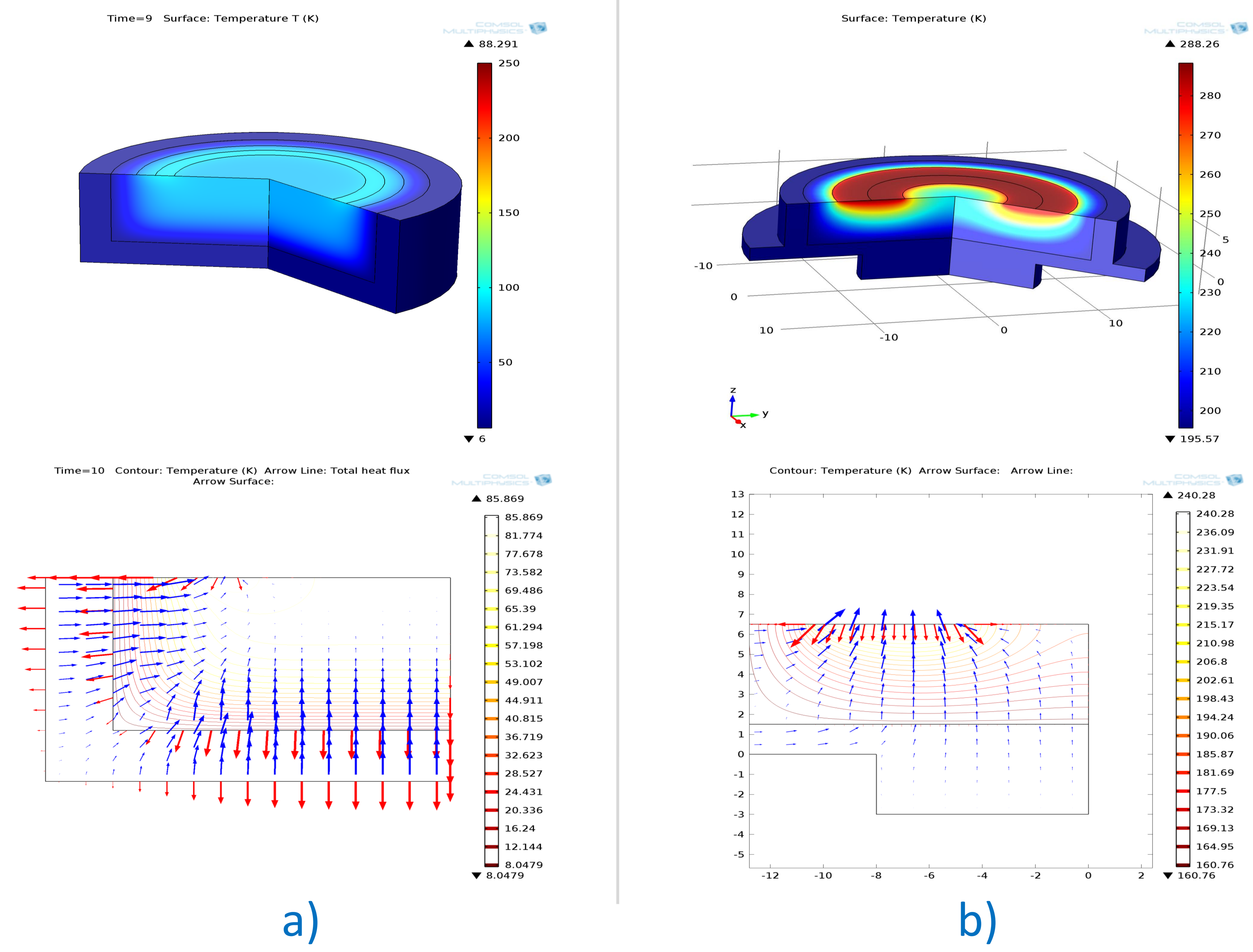

Figure 3. Temperature distribution and arrow representation
a) with PTR b) with LN2

Results:

The thermal distribution in the LN2 cooling sys goes above 260 K after 50sec (Fig.3b), while PTR sys is around 87K (Fig. 3a)

Computational Methods:

For the Copper target cooled through an adjacent holder the thermal distribution within the laser target is governed by the Eq.1…3 [2]:

$$\rho(T)\cdot C_P(T)\frac{\delta T(x,z,t)}{\delta t} = \nabla\cdot[k(T)\cdot\nabla T(x,z,t)] + Q(z,t) \quad (1)$$

$$Q(z,t) = I_S(z,t)\times(1-R)\times A_C\exp(-A_C z) \quad (2)$$

$$I_S(z,t) = I_0(z,t)exp\left(\frac{-3.5(t-\tau_m)}{\tau^2}\right)exp\left(-\frac{x^2}{r^2}\right) \quad (3)$$

From equation 2, *Q(z,t)* was written using the *variables* section of COMSOL, under *model 1* for the DMSO domain, as:

Q_target = I(1-Rc)*Ac*exp(-Ac(z))*an2(t)* (4)
I=I0*Gauss_time(t)*Gauss_space(r) (5)

where: *Gauss_time* and *Gauss_space* are analytical functions defined in the *global definitions* as (Fig.4):

Gaus_time = exp(-3.5((t-tau_m)*(t-tau_m))/(tau_m*tau_m))

Gauss_space = exp(-(r^2/r0^2))

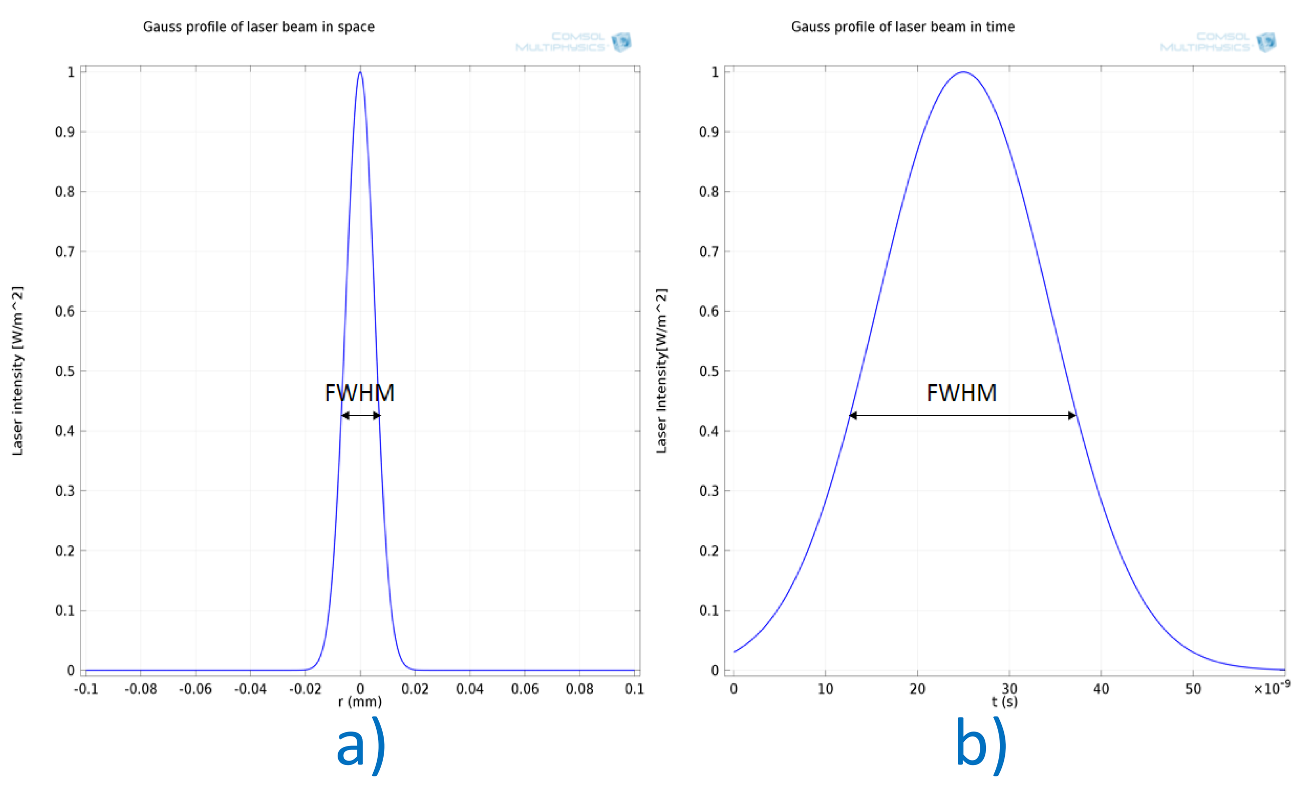

Figure 4. Gaussian Laser profile
a) in time b) in space

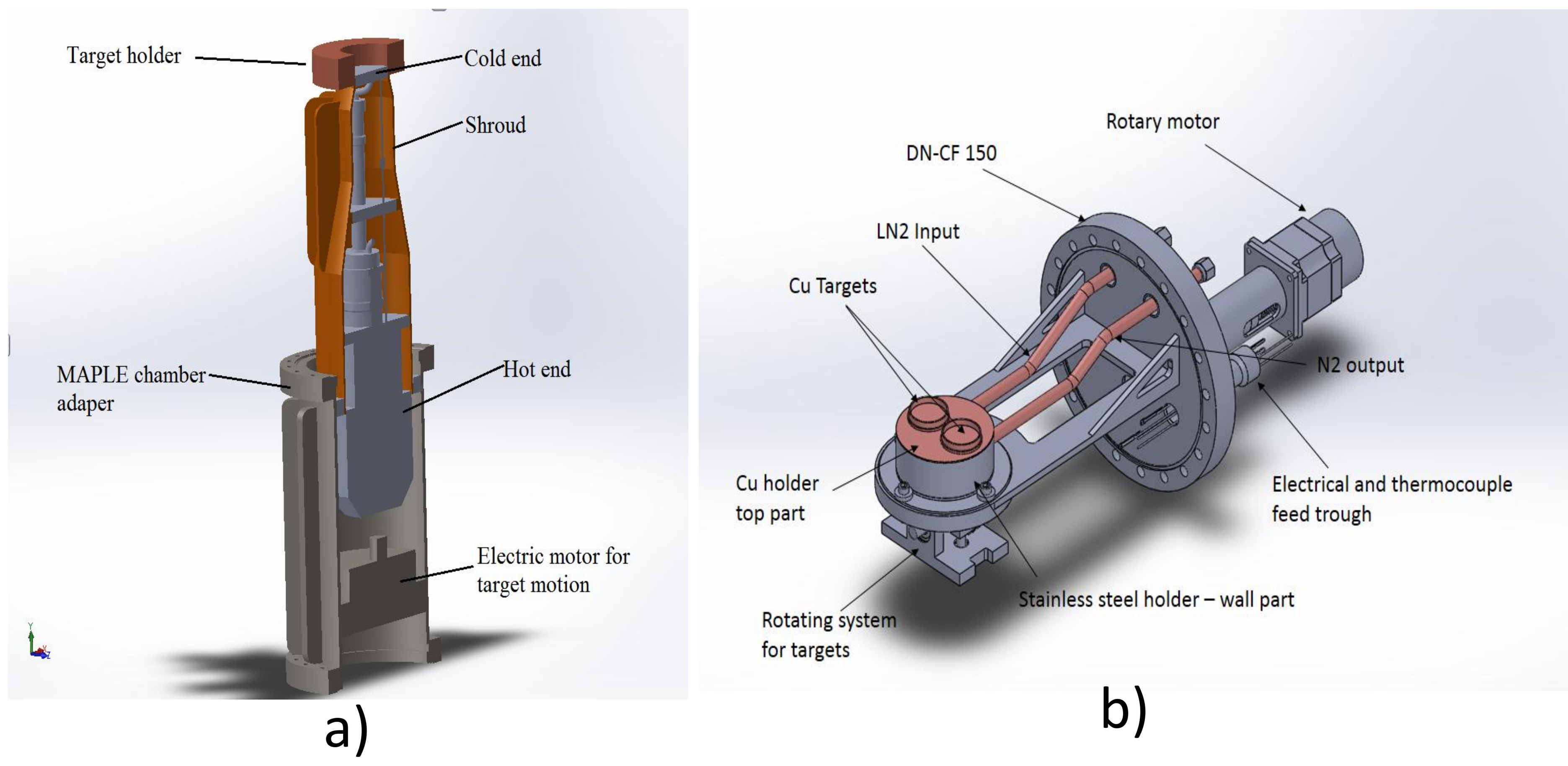

Figure 5. Methods of target cooling: *a) PTR b) LN2*

Conclusions:

The use of PTR is more effective: with the liquid N_2 cooling system the temperature of the target goes above the melting point of DMSO, while by the use of PTR cooling system the temperature of the target stays well below this threshold.

References:

1. http://www.comsol.com/model/laser-heating-a-self-guided-tutorial-12317, last viewed on 15.08.2013
2. *J. H. Bechtel,* Heating of *solid targets with laser pulses,* Journal of Applied Physics, vol. 46, no. 4, pp. 1585–1593, Apr. 1975.