Nanostructured material in Dielectric Laser Accelerator

Chaudhry, F.A, Lopez-Calle, I

In dielectric laser accelerator (DLA), an incident laser light over the nanostructure, generate an attractive electric field in the way of the electrons. The grating structure is utilized to generate an electromagnetic surface wave that travels synchronously with electrons.

In this work we present the electron energy gained using different materials with the dimensions of nanostructured grating to use in DLA.

The dimensions of binary grating (see figure 1) are calculated by simulation, that satisfy the condition.

$$T = n \cdot \beta_{e^-} \cdot \lambda \quad (1)$$

where T is the nanostructure period, β_{e^-} the initial velocity of electrons, λ the laser wavelength and *n* is the spatial harmonic.

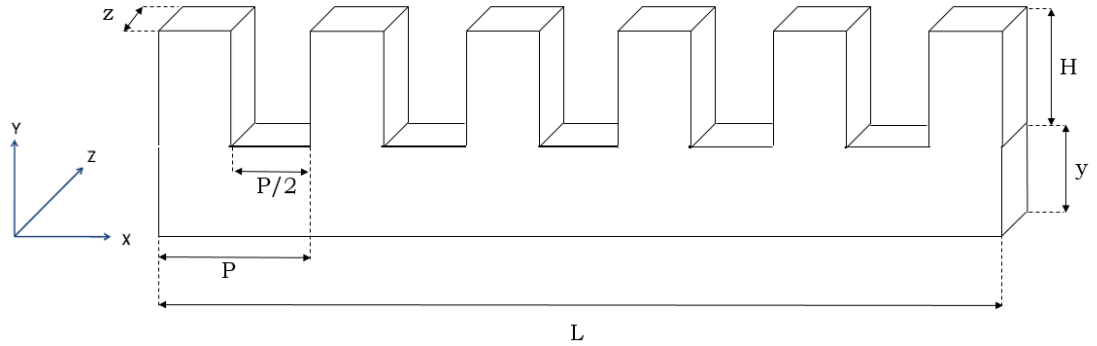

Figure 1. Binary grating structure (not to scale) where P is the period, H the pillar height and L the grating length.

In table 1 we show the laser and electron gun characteristics of our DLA experiment

Table 1. Input parameters according to the instrumentation to use. Thorlabs Picosecond Microchip Laser QSL103A and 3 KeV Varian 981-2454 Electron Gun.

e-beam energy	3000	eV
Area spot	1.96	um2
Laser Pulse Energy	45	µJ
Pulse duration	500	ps
Wavelength	1030	nm

In table 2 we present the simulation results for the first and third harmonic taking into account the data showed in table 1 and equation (1).

The maximum fluence for the laser is below the threshold damage of the material. There is no data for the threshold damage using a laser with same parameters. So we have considered the maximum fluence measured with other laser at the same wavelength but minor pulse duration given by Gallais & Commandré (2013) [1], Thorstensen & Erik Foss (2012) [2] and Žukauskas et al (2014) [3] at 1030 nm and 500 fs, 3 ps and in fs range for SiO_2, Si and Ormocomp respectively.

Table 2. Results obtained for different materials at maximum laser fluence. P is the grating period, L is the length of the grating.

	Material	Refractive index	Threshold damage (J/cm^2)	P (nm)	Number of periods	L (nm)	Energy gain (MeV/m)
1st harmonic	SiO_2	1.45	2.92 [1]	115	17	1955	86
	Si	3.5	0.24 [2]	113	30	3390	28
	Ormocomp	1.5	0.33 [3]	114	27	3078	53
3rd harmonic	SiO_2	1.45	2.92 [1]	340	20	6800	28
	Si	3.5	0.24 [2]	338	18	6084	9
	Ormocomp	1.5	0.33 [3]	338	12	4056	11

References

1. Gallais, L., & Commandré, M. (2013). Laser-induced damage thresholds of bulk and coating optical materials at 1030 nm, 500 fs. Applied Optics, 53(4), A186. doi:10.1364/ao.53.00a186

2. Thorstensen, J. & Erik Foss, S. (2012). Temperature dependent ablation threshold in silicon using ultrashort laser pulses. Journal of Applied Physics, 112(10), 103514–. doi:10.1063/1.4766380

3. Žukauskas, A., Batavičiūtė, G., Ščiuka, M., Jukna, T., Melninkaitis, A. and Malinauskas, M. (2014). Characterization of photopolymers used in laser 3D micro/nanolithography by means of laser-induced damage threshold (LIDT). Opt. Mater. Express 4, 1601-1616. https://doi.org/10.1364/OME.4.001601

This work has been co-financed by the European Union under the 2014-2020 ERDF Operational Programme and by the Department of Economic Transformation, Industry, Knowledge, and Universities of the Regional Government of Andalusia. Project reference: FEDER-UCA18-107049