

Theoretical Optimization of Metal Mesh THz-Filters for Selecting Harmonics of NovoFEL Radiation

Sergei A. Kuznetsov^a and Petr V. Kalinin^a

^aBudker Institute of Nuclear Physics SB RAS, Novosibirsk State University, 630090 Novosibirsk, Russia

Abstract—The report is devoted to theoretical optimization of geometric parameters of high-pass and band-pass THz-filters for selecting 2nd and 3rd radiation harmonics of Novosibirsk terahertz FEL. Using Chen's theory and HFSS electrodynamic software we analyze the filtering properties of thick free standing copper meshes with different geometry of mesh cells. The results of optimization are planned to be used for producing mesh filters by LIGA-technology developed in the Siberian Synchrotron Radiation Centre.

I. INTRODUCTION AND BACKGROUND

NOVOSIBIRSK terahertz free electron laser [1] operating at the Siberian Photochemical Center is considered to be the most powerful modern THz-FEL which average power of the fundamental radiation harmonics ($\nu=1.3\dots2.5$ THz) reaches 500W nowadays and is expected to be raised in the future. Possibility of generating the 2nd and 3rd radiation harmonics with relatively high values (2 % and 0.6 % respectively [2]) effectively triples the NovoFEL radiation spectrum and is considered to be important for some user experiments where short-wave radiation is required.

For quasi-optical filtering higher radiation harmonics at simultaneous strong suppression of the fundamental one the free standing substrate-free inductive metal meshes [3, 4] are very effective. In this work we search for optimal geometrical parameters of mesh filters for selecting the 2nd and 3rd harmonics at minimal number of filters used. The results of optimization are planned to be used for producing mesh filters by LIGA-technology developed in the Siberian Synchrotron Radiation Centre (BINP SB RAS). The LIGA is considered as the only alternative to conventional photolithography and electroforming techniques which do not allow one to create high-aspect thick mesh structures that leads to increasing a number of meshes used for NovoFEL's harmonics selection.

II. RESULTS

The Chen's theory and HFSS v.11 electromagnetic software were used for optimization. The main stress was set on analysis of high-pass filters based on single nonresonant meshes satisfying criteria: a) maximization of the transmission spectral range with transmittance > 75 %; b) 1st harmonics suppression > 40 dB; c) > 20 dB-isolation of the 2nd and the 3rd harmonics when transmission of only the 3rd one is required; d) minimization of the total number of meshes, their ohmic losses and aspect ratio. Analysis of meshes with square, round and hexagon openings let us single out the best solution: four hexagon (honeycomb) mesh filters which $d:s:l$ -ratios and the aspect ratio $l/(s-d\sqrt{3}/2)$ are 1:1.14:1.63 and

5.95 respectively (see Fig.1).

The honeycomb filters #1, 2, 3 from Fig.1 are recommended for >40 dB suppression of the 1st harmonics when its frequency lies in the range 1.25-1.67 THz, 1.67-2.08 THz, 2.08-2.5 THz respectively. The filters #2, 3, 4 are to be used for transmitting the 3rd harmonics in conditions of >20 dB attenuation of the 2nd one when its frequency falls within the range 2.5-2.92 THz, 2.92-3.75 THz, 3.75-5.0 THz respectively. If suppression of the 3rd harmonics is desired against the background transmission of the 2nd one the resonant mesh filters should be used. Their parameters are at the stage of optimization at present.

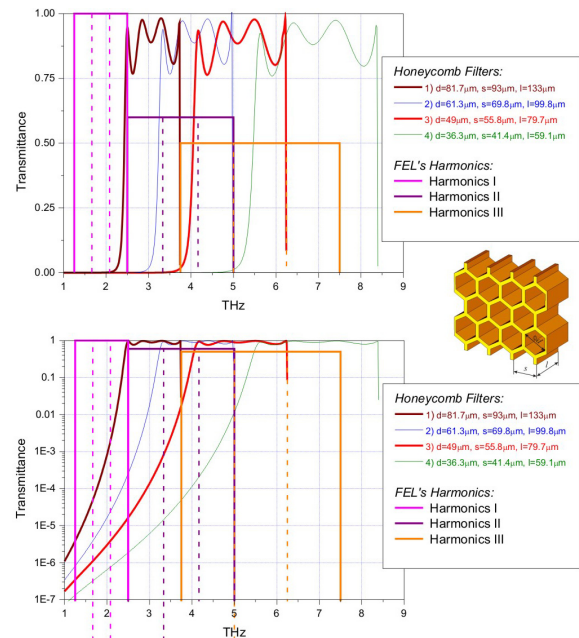


Fig.1. Frequency response of optimized honeycomb filters.

REFERENCES

- [1] V.P. Bolotin, N.A. Vinokurov, D.A. Kayran et al., "Status of the Novosibirsk terahertz FEL", Nuclear Instrum. Methods, vol. A543, pp. 81-84, 2005.
- [2] V.V. Kubarev, N.A. Vinokurov, V.V. Kotenkov et al., "Harmonic Generation in the Novosibirsk Terahertz Free Electron Laser", Proc. Joint IRMMW-THz-2006 Conf., Shanghai, China, 2006, p. 162.
- [3] S.A. Kuznetsov, V.V. Kubarev, P.V. Kalinin, and N.A. Vinokurov. "1-D and 2-D metal mesh based quasi-optical selective components for high-power applications at Novosibirsk terahertz FEL" Conf. Digest of Joint "IRMMW-THz 2007" Conf., Cardiff, UK, 3rd-7th September, 2007, Vol. 1, pp. 303-304.
- [4] S.A. Kuznetsov, V.V. Kubarev and P.V. Kalinin, "Electroformed Metal Mesh THz-Filters for Selecting Harmonics of NovoFEL Radiation", in these Proceedings.