

Electroformed Metal Mesh THz-Filters for Selecting Harmonics of NovoFEL Radiation

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Abstract—In this report we present the results of experimental development and investigation of high-pass THz-filters for selecting higher radiation harmonics of Novosibirsk terahertz FEL. The filters are based on free standing nonresonant electroformed Ni-meshes a few tens microns thick with hexagonally packed round openings. The results of FT-characterization are being compared with results of electrodynamic simulations and direct measurements in high-power experiments at NovoFEL.

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 ($\nu=1.3\dots 2.5\text{THz}$) reaches 500W nowadays and is expected to be raised in the future. Measurements show [2] that along with the fundamental harmonics the NovoFEL radiation spectrum contains the higher spectral components. In spite of small relative power of the higher harmonics ($\sim 1\%$) their absolute value is considered to be high enough for some user experiments where short-wave radiation is required.

Under high-power load conditions the most appropriate high-pass filtering of the higher radiation harmonics (first of all the 2nd and the 3rd ones) can be provided by free standing self-bearing metal meshes of the nonresonant type [3, 4]. For such meshes increase of metallization thickness results in both improving their mechanical fastness and thermostability and augmentation of low-frequency attenuation due to a waveguide cut-off effect. For 40-50dB attenuation required for suppression of the 1st NovoFEL harmonics the thickness of a single mesh and its aspect ratio a should be $\sim 100\mu\text{m}$ and ~ 6 respectively [5]. The only technology adequate for manufacturing such thick mesh filters is LIGA [4]. This promising technique is at the stage of mastering in the Siberian Synchrotron Radiation Centre (BINP SB RAS). The alternative approach for mesh production is based on techniques of conventional photolithography and electroforming which are cheaper but enable to obtain only low-aspect ($a \leq 1$) mesh structures.

In our previous works [3, 4] we used the latter techniques for manufacturing THz-filters based on free standing Ni-meshes with hexagonally packed round openings $9\mu\text{m}$ thick ($a=0.3\dots 1$). In this report we present the new results of experimental development and investigation of electroformed 80x80mm CA-area Ni-mesh high-pass filters with improved characteristics that is provided by increasing metallization thickness up to $45\mu\text{m}$ and the mesh aspect ratio a up to 2.

II. RESULTS

Fig.1 illustrates typical FIR transmission spectra of manufactured mesh filters obtained at the “Bruker IFS 66v/s” Fourier-transform spectrometer. For increasing mesh aspect ratio up to values $a=1\dots 2$ the “geometrical” transparency of the filters was decreased down to $47\pm 26\%$. Along with strengthening low-frequency attenuation it resulted in dropping transmittance of frequencies above the diffraction point down to 10%. We also observed degradation of transmittance maxima as a grows.

At present the results of FT-characterization are being compared with results of electrodynamic simulations based on HFSS v.11 electromagnetic software. The practical effectiveness of the filters is planned to be checked directly in the future high-power experiments at NovoFEL.

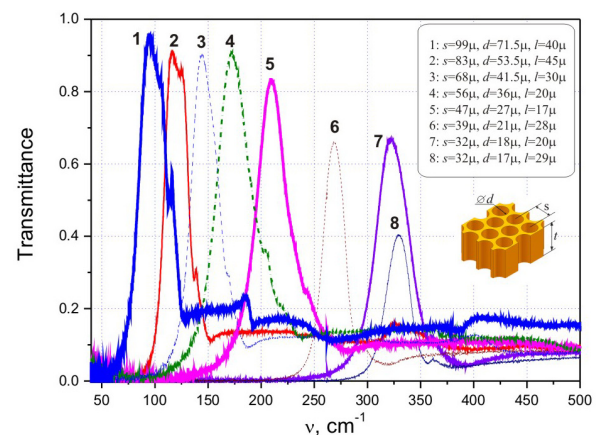


Fig.1. Frequency response of manufactured THz-filters.

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