# Flexible Terahertz Metamaterial Narrow Bandpass Filter

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Electromagnetic metamaterials have been fabricated to obtain material properties that are not available in naturally existing conventional materials. These are composed of micro- and nano-structures exhibiting the required values of permittivity and permeability in a desired frequency regime. Metamaterials in terahertz (THz) frequency regime have attracted much attention due to its potential application in lenses, switches, filters, modulators and detectors [1-5]. One of the important devices in the THz range is bandpass filters. These could be widely used in the field of imaging, spectroscopy, molecular sensing, security, drug identification.

In this paper, a multi-layered flexible THz metamaterial narrow bandpass filter is proposed, fabricated, and demonstrated. The key idea of the metamaterial filter is that it consists of a combination of three metallic layers filled with the polyimide substrate. The top and bottom layers have a fishnet metallic structure working as a high-pass FSS (frequency selective surface) with 40μm unit cell and line width 5μm and the mid-layer as a low-pass FSS has complementary metallic structure of the outer fishnet layers as shown in Fig. 1. The simulated transmission spectra of the single fishnet layer, the single square layer (complementary structure of fishnet), and the composite three layer as shown in Fig. 2.(a) reveal the function of each layer. The sharp transmission peak is obtained near at 1 THz frequency. It is also shown in Fig. 2.(b) that the transmission and the operating bandwidth can be tuned by adjusting the interlayer spacing parameter (s).

The transmission properties are calculated by the finite-difference time-domain (FDTD) method, adopting the Drude model to take into account the dispersion of metal in THz regime. The single layer of metamaterial filter is fabricated by Au/Cr metal patterning with 100 nm thickness using photolithography, e-beam metal deposition, and lift-off process on the polyimide substrate. The multilayered structure is completed by repeating the above single-layer processes. Experimentally, the transmission spectra of the metamaterial filter were measured by using the THz Time-domain spectroscopy (TDS) with the frequency window from 0.2 to 2.5 THz.

In conclusion, we introduced the flexible narrow bandpass filter designed through intuitive and robust method using the fishnet metamaterial layer and its complementary layer. It will be expected to be used in various THz optical applications.

This research was supported by the Nano R&D Program (2010-0019170)) through the National Research Foundation of Korea funded by the Ministry of Education, Science and Technology

## References


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## Figures

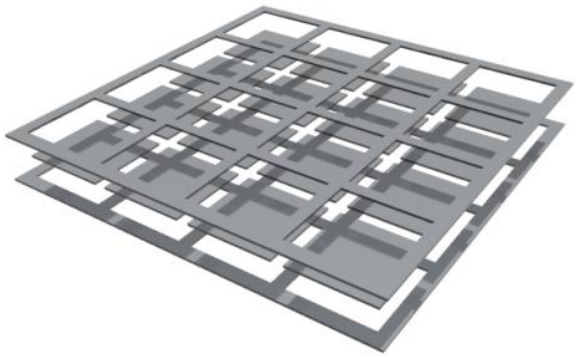

**Fig. 1**: The schematic of the metamaterial narrow bandpass filter with triple layers. Top and bottom layers are fishnet metal layer with 40μm unit cell and line width 5μm, and mid-layer is the complementary structure of the fishnet layer.

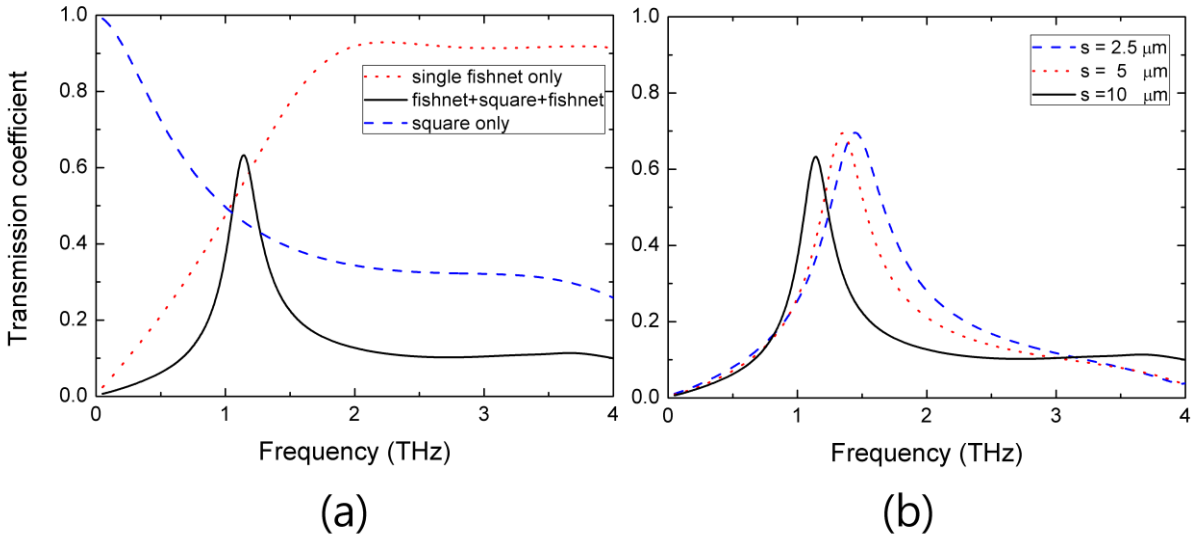


**Fig. 2**: (a) Simulated transmission spectra of the metamaterial filter (black solid line), the square layer only (blue dash line), and the single fishnet only (red dot line). (b) Simulated transmission spectra of the metamaterial filter with varying interlayer spacing (s) as 10 μm (black solid line), 5 μm (blue dash line), and 2.5 μm (red dot line), respectively.