Metamaterial bandpass structures made of two-dimensional arrays of planar resonators

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***Abstract*—Planar arrays of λ/2 open crosses designed for quasioptical filters in 300, 350, 450, 600 GHz bands were fabricated and experimentally studied. Such metamaterial structures were fabricated as a free-standing Cu foil, or copper films evaporated on kapton and quarts substrates using direct lithography and chemical etching or lift-off technology. High-pass cutoff waveguide array structure was fabricated of short pieces of capillaries. Pass-band properties are strong dependent on film thickness and processing type, as well as on distance between crosses. Varying these parameters the bandwidth can be reduced from 30% to 3%. Filter fabricated on a capton substrate was used for cryogenic sensitivity calibration of array of cold electron bolometers at 300 GHz.**

I. Introduction And Background

PLANAR periodic structures on flexible substrates become popular for developing flexible fishnet metamaterials at terahertz frequencies [1]. Earlier patterned mesh filters were designed and fabricated as bandpass filters in terahertz frequency band [2]. Fabrication technology was based on direct lithography and chemical etching of Cu and Al foils that always brings overetching and thinning of edges. Lift-off technology with magnetron sputtering brings sharper edges, but is limited in thickness of films.

In this paper we report on studies of such structures with different spacing between crosses that allows varying passband from 30% to 3%. Quality factor was improved also by fabricating such fishnet on capton substrate with copper films up to 2 μm thick chemically etched in water solution of H_2O_2 and HCl. For higher frequencies requirements of higher resolution led to using image reversal lift-off technique for e-gun evaporated golden films on thin quartz substrates.

II. Results

Optical image of such band-pass mesh fabricated on quarts substrate is presented in Fig. 1. Transmission of fabricated samples was measured using a backward wave oscillator (BWO) as signal source. For improving of accuracy instead of scanning over the whole band 220-375 GHz we use substitution technique at spectral points with largest signal. Fitting of the obtained data points by Lorentz line shape brings the results presented in Fig.2. Comparison of transmission and losses in measured samples led to a simple model of losses accounting the shape of film edges. Main currents responsible for transmission are induced inside the loop at its edges. Taking into account the narrow side of the loop with the current maximum, skin-depth and thickness of the film we estimated the resistance and losses in the loop.

Finally we use such filters as a frequency-selective part of cryogenic Planck radiation source for calibration of a cold electron bolometer array [3].

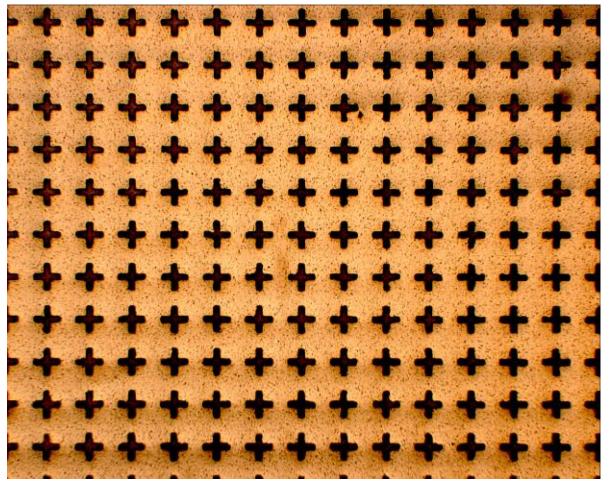

Figure 1. Optical image of a 345 GHz structure

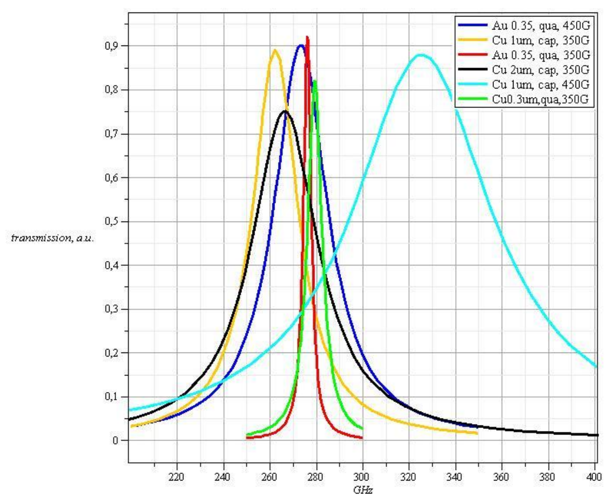

Figure 2. Transmission of several filters

References

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