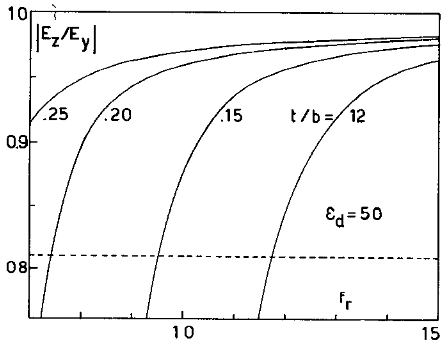

Fig. 4. Frequency dependence of the ratio $|E_z/E_y|$ in air over a high-permittivity lossless dielectric.

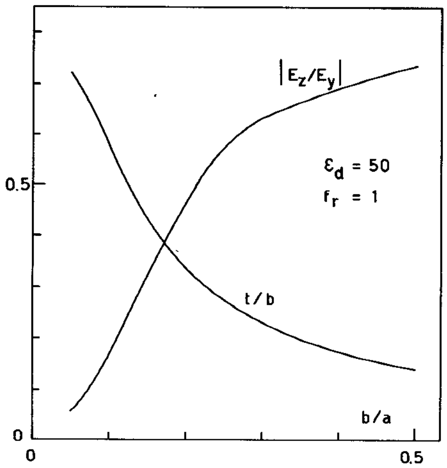

Fig. 5. Effect of the waveguide aspect ratio b/a on the maximum allowable filling factor t/b at the LSM_{21} cutoff and corresponding (maximum) ratio $|E_z/E_y|$.

high-permittivity dielectric does not increase the bandwidth. The waveguide loading needed to provide circular polarization is small enough to ensure single-mode operation [5].

When thick high-permittivity slabs are utilized, the electric field in the air next to the dielectric is almost circularly polarized over a much larger frequency range (Fig. 4). This effect could be quite useful for experiments involving thin gaseous plasmas. Unfortunately, it occurs at frequencies larger than the cutoff of higher order modes, hence particular precautions would be needed to avoid their excitation. The possibility of varying the waveguide aspect ratio b/a in order to raise the cutoff frequency of the first higher order mode was considered. For the particular range of interest, this mode is the LSM_{21} mode (quasi-TE_{20}), the cutoff frequency of which occurs when [5]

$$\beta_{11} = \sqrt{3}\pi/a \simeq 5.44/a \tag{5}$$

where β_{11} is the phase coefficient of the propagating dominant LSM_{11} mode. Computations were carried out to determine the effect of the aspect ratio b/a. The reduction of height, keeping the same filling factor t/b, does actually raise the LSM_{21} cutoff frequency. Alternatively, at one given frequency, operation with a larger filling factor would be possible. Unfortunately, it also decreases the ratio E_z/E_y at the interface. This effect is illustrated in Fig. 5, which presents at one fixed frequency ($f_r = 1$) the filling factor t/b and the corresponding ratio E_z/E_y at the LSM_{21} cutoff as a function of aspect ratio b/a. It is quite clear that height reduction is not suited to avoiding higher order modes, as it affects quite adversely the occurence of circular polarization.

IV. CONCLUSION

Loading a rectangular waveguide with a thin slab of low-loss dielectric provides a simple means for obtaining circularly polarized electric fields. This effect could be used to reduce the losses of nonreciprocal semiconductor devices and to study gyroelectric properties in semiconductors and gaseous plasmas.

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A 40–120-GHz Michelson Interferometer-Type Band-Splitting Filter

NOBUO SUZUKI

Abstract—**The experiments of a Michelson interferometer-type filter with a superbroad frequency range 40–120 GHz are described. The branching loss is 1.2–2.2 dB within this frequency range. The filter can be used for a 40–120-GHz millimeter-wave waveguide transmission system.**

A millimeter-wave waveguide transmission system uses a frequency range from 40 to 120 GHz and requires three kinds of band-splitting filters with different bandwidths, 20, 40, and 80 GHz, to split the band into eight sub-bands [1]. Several band-splitting filters have been proposed [2]–[5]. These filters have been verified for the bandwidth 20 or 40 GHz. But, in order to increase the bandwidth more than 40 GHz (80 GHz, say), a Michelson interferometer-type filter may only be the device that meets these requirements.

This filter was first reported by Marcatili and Bisbee and experimentally tested in frequency range from 40 to 80 GHz [5]. Iiguchi developed the design theory of the filter [6].

This short paper describes the more detailed experiments of the filter whose bandwidth is 80 GHz, and gives data useful enough to design for the practical use.

This filter consists of Michelson interferometer-type hybrid circuits which are based on the concept of quasi-optical technique, two cutoff filters with high-pass responses, and other components as shown in Fig. 1. The frequency band from f_L to f_H (f_L,f_H: the lowest and highest frequencies of the band, respectively) coming in at port W is split into two sub-bands, the lower band from f_L to f_C (f_C: cutoff frequency of the cutoff filter) which emerges from port L and the higher band from f_C to f_H which emerges from port H, respectively.

First, the wave in the lower band is not related to the hybrid H_B because it only round trips in the hybrid H_A. Therefore, the hybrid H_A can be designed such that the coupling deviation in the band

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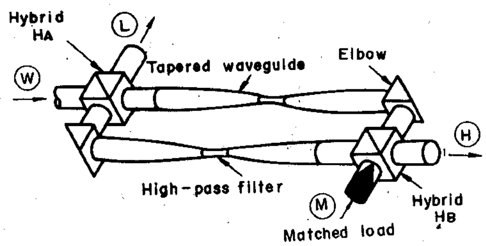

Fig. 1. A Michelson interferometer-type band-splitting filter.

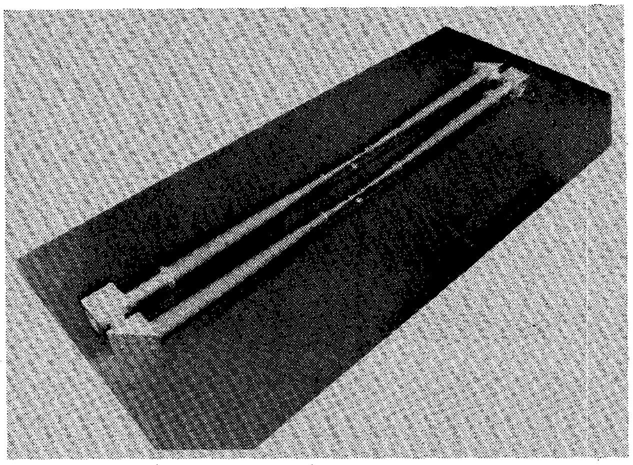

Fig. 2. 40–120-GHz filter.

$f_L - f_C$ will be as small as possible. On the other hand, since the wave in the higher band goes through the hybrids H_A and H_B, the hybrid H_B can be designed such that the overall coupling characteristics of the cascade connection of both hybrids will be 0 dB. In this case, the coupling deviation in the band $f_C - f_H$ must be designed to be as small as possible. Taking this method, we can design the hybrids which double the usable bandwidth as compared to the conventional filters.

This new design method, after all, is to make the coupling characteristics of the hybrids H_A and H_B different from each other: an optimum dielectric constant and thickness of the semitransparent mirror of each hybrid must be properly chosen in a given frequency band. Using the hybrids and cutoff filters, we have constructed a band-splitting filter shown in Fig. 2, whose specifications are as follows:

frequency range	40–120 GHz
cutoff frequency	76.15 GHz
semitransparent mirrors	H_A:F2 glass ($\epsilon_r = 7.2$; $h = 0.41$ mm)
	H_B:potash–soda–glass ($\epsilon_r = 6.8$; $h = 0.27$ mm)
taper profile of cutoff filter	cosine to the third power
waveguide diameter	51 mm
overall length	2.67 m

Experimental results of the filter are shown in Fig. 3. Its branching characteristics are flat. The branching loss is 1.37–2.22 dB in the lower band (*W–L*, 40–76.15 GHz) and 1.16–1.62 dB in the higher band (*W–H*, 76.15–120 GHz). A reflection coefficient in the lower band is below −20 dB (VSWR: below 1.22), residual coupling in the higher band is below −13 dB (below −20 dB in 76.15–110 GHz), and the guard band is as small as 348 MHz.

It is concluded that a Michelson interferometer-type band-splitting filter can be used for a 40–120-GHz millimeter-wave waveguide transmission system.

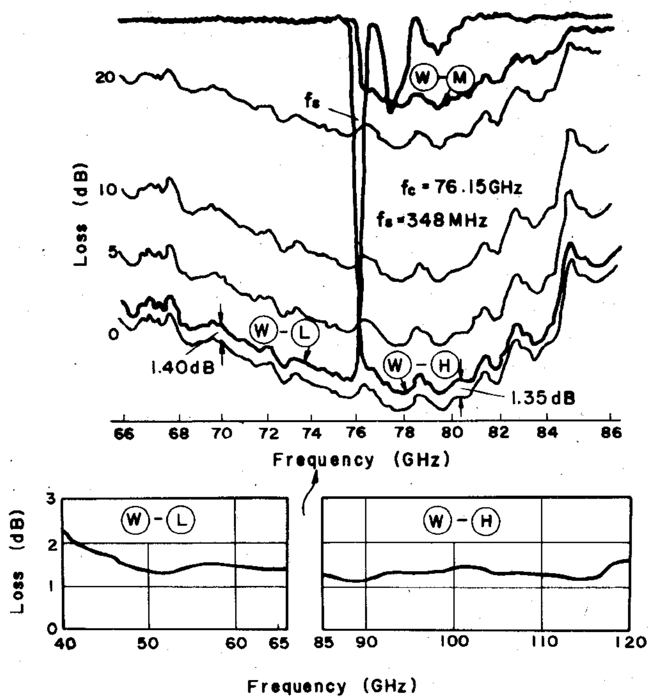

Fig. 3. Measured frequency responses.

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Excess Surface Resistance Due to Surface Roughness at 35 GHz

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Abstract—**The increase of the surface resistance of plane copper surfaces caused by mechanically generated surface roughness has been determined at 35 GHz by measuring and evaluating the *Q* values of an *H*-guide cavity with removable sidewalls. The sidewalls were ground one-directionally by using abrasive papers of various**

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