

INTERFERENCE MICROFILTERS FOR REMOTE SOUNDING OF NATURAL ENVIRONMENTS

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*Spectral characteristics are presented for interference filters of different types
manufactured at the Science and Production Association "Taifun" for operation in
the spectral range from 0.25 to 13 μm .*

In recent decades, airborne and spaceborne monitoring is accepted as the best choice for studying natural environments (the atmosphere, clouds, forests, fields, pastures, water basins, etc.). Recording of an object of interest in different spectral ranges becomes common practice for distinguishing among different states of natural environments.

Interference filters of various types may serve as a basis for the design of fast-operation highly sensitive equipment needed in such studies.

The Institute of Experimental Meteorology SPA "Taifun" has succeeded in the development and manufacturing of optical elements on the basis of multilayer interference filters operating in the spectral

range from 0.25 to 13 μm . Optical characteristics of the filters are given in Table I. Besides, microfilters, which are directly placed onto linear CCD arrays and other detectors of radiation, have been developed. Such filters are used in spaceborne instrumentation.

At present two types of microfilters with four and six spectral channels on the same substrate have been developed. The filters are designed as a glass substrate with opaque mask and windows with interference coating (see Fig. 1). In the four-channel modification, windows with interference coating are 0.45 mm wide spaced by 0.57 mm; in the six-channel version, windows are 0.20 mm wide spaced by 0.25 mm.

TABLE I.

Filter type	Wavelength range, μm	Peak transmission, %	FWHM, μm	Off-band blocking, %	Filter size and configuration, mm
Narrowband	0.25–0.4	15–35	1.5–5	10^{-2} – 10^{-3} (0.2–0.8 μm)	10–30
	0.4–0.9	40–80	0.5–5	10^{-3} – 10^{-4}	"
	0.9–1.5	40–80	1–3	"	"
	1.5–3.5	40–60	1–5	"	"
	3.5–5.5	30–60	"	"	"
	5.5–13	30–50	"	"	"
Super-narrowband	0.4–4	30–50	Several Angs	"	"
Bandpass	The same as for the narrowband filters	40–70	5–10	The same as for the narrowband filters	"
Edge	0.4–0.7	20–40	2–4	10^{-2} (0.2–6 μm)	
Round (passband is a linear function of the rotation angle)	0.7–1.2	20–40	2–4	"	$R_1 = 50$
	1.1–2.0	30–40	"	"	$R_2 = 15$
	1.9–3.2	30–40	1–2	"	The presented spectral ranges correspond to sector substrates
	3.0–5.3 8–13	20–40 20–40	" 3–4	" < 1 (0.2–15 μm)	at 180 or 90°

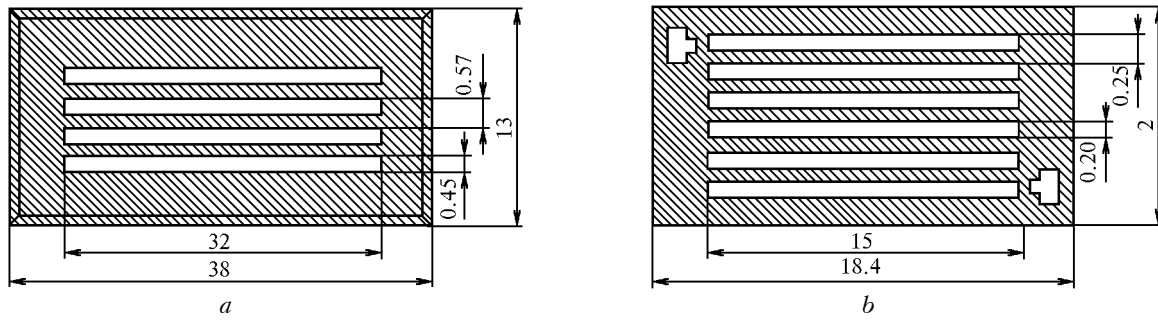


FIG. 1.

TABLE II. Spectral characteristics of filters.

Channel	$\Delta\lambda_{0.1}, \mu\text{m}$	$\lambda_{\text{centr}}, \mu\text{m}$	$\Delta\lambda_{0.5}, \mu\text{m}$	$\tau, \%$	$\lambda_{\text{sw}}, \mu\text{m}$	$\lambda_{\text{lw}}, \mu\text{m}$
four-channel filter						
1	0.49–0.52	0.505	0.5–0.51	} more than or equal to 50	0.4	1.1
2	0.52–0.60	0.560	0.54–0.53		0.4	1.1
3	0.63–0.67	0.650	0.67–0.66		0.4	1.1
4	0.80–0.90	0.850	0.83–0.87		0.4	1.1
six-channel filter						
1	0.80–0.90	0.85	0.81–0.89	} more than or equal to 50	0.4	1.1
2	0.49–0.52	0.505	0.495–0.515		0.4	1.1
3	0.52–0.60	0.56	0.53–0.59		0.4	1.1
4	0.63–0.67	0.65	0.635–0.665		0.4	1.1
5	0.71–0.73	0.72	0.715–0.725		0.4	1.1
6	0.76–0.80	0.78	0.765–0.795		0.4	1.1

Note: $\Delta\lambda_{0.1}$ is the spectral width of the filter passband at the level of 0.1 τ , in %; $\Delta\lambda_{0.5}$ is the spectral width at the level of 0.5 τ , %; λ_{centr} is the central wavelength of the passband; τ is transmission; λ_{sw} and λ_{lw} are the short-wave and long-wave edges of the passband, respectively.

Using these linear arrays, arrays may be constructed for recording images in different wavelength ranges. Spectral characteristics of the filters designed at SPA "Taifun" are presented in Table II.

These spectral characteristics have been achieved by use of additional interference bandpass and cut-off systems constructed of alternating layers with the quarter-wave optical thickness of high and low refractive index materials.

Interference layers are deposited by evaporation in vacuum through specialized narrow slits of the needed size onto a substrate. The substrate is coated with the opaque chrome layer with narrow transparent windows spaced by a certain interval (see Fig. 1). To achieve the needed spectral characteristics, advantage is taken of the

theory and technology similar to those used in manufacturing of usual filters. The only difference is that the described filters do not allow the use of natural off-band blocking of several substrates (color glasses) to suppress spurious passbands of major interference systems. As a result, some additional cut-off interference systems should necessarily be deposited on and matched with each other. Thus, the manufacture technology becomes more complicated.

The spectral characteristics tabulated in Table II (wavelength ranges, spectral widths, and others) are not the only possible. The technology developed allows manufacturing of filters for use in other systems of remote sounding and object recognition in different spectral ranges: UV, visible, and infrared.