2.4. SEARCH EQUIPMENT BASED ON ELECTROMAGNETIC RADIATION OF TERAHERZ BAND

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Paper is devoted to study of possibilities of methods and means based on application of teraherz radiation with respect to solution of problems of search and detection of prohibited objects in optically nontransparent media.

Interest displayed to teraherz band is explained by new opportunities in solution of multiple problems in electromagnetic spectrum areas, which were not used previously. Currently, teraherz band is understood to be the part of spectrum approximately from 0.1 to 10 THz. Previosly, this part of spectrum was called as millimeter-wave, submillimeter-wave and optical band. New radiation sources and receivers begin to appear in this band, which allows respective studies with oractical realization of results to be carried out. Developments in the field of remote spectroscopy for identification of various substances, diagnostics of hidden items with possibility of their qualitative visualization have appeared already, including solution of many new problems in the field of non-destructive testing.

Radiation of teraherz band is governed by known laws of electrodynamics and optics. However, selection of the particular part of this band is conditioned by the specificity of resolved problem, i.e. the necessity of achievement of sufficient contrast in order to detect required objects on the background of structural noises. The higher is frequency, the better is quality of expected image. However, search depth decreases in the result of general attenuation and scattering by structural irregularities. When electromagnetic radiation interacts with real objects and media, its intensity, amplitude, phase, polarization, as well as intensity distribution over spectrum varies. In most cases, reflection methods are used as only possible ones with unilateral access to an object.

Interaction of electromagnetic radiation with objects is featured by its penetration through various non-metal obstacles with formation of interference and diffraction fields to be taken into account during analysis of radio-images. During interaction with metal obstacles, electromagnetic radiation is reflected practically completely penetrating to the depth of “skin-layer” only. However, maximal contrast is provided during detection of metal embeddings in dielectric media.

Analysis of performed works demonstrates possibilities of teraherz spectroscopy methods to detect remotely packs with explosive and narcotic substances concealed behind clothes, hidden metal and non-metal items (ceramic arms, for example) by means of coherent and non-coherent visualization of reflected-scattered radiation, as well as to detect various embeddings in near-surface layers of building enclosing structures.

Visualization of radio-images is implemented under several methods: line-by-line scanning with single receiver of scattered radiation; application of line of detectors and arrays.

It should be added that active and passive methods are developed in equal extent. However, during indoor operation, passive methods require “backlighting” in order to increase contrast.

During solution of the number of anti-terroristic problems, we have used active reflection method in the long-wavelength section of the teraherz band spectrum ($\lambda \approx 3$ mm). For visualization of radio-images, multi-element receiving line based on the Schottky-barrier diodes was applied. Increase of image contrast was achieved due to application of polarization method.

Experimental 3 mm band installation contains single transceiver module, scanning device and visualization means. Transceiver module has dielectric lens for radiation focusing at the distance of 250 mm in order to ensure resolution at various depth of object occurrence. Polarization of receiving element is selected to be orthogonal to incident radiation.

Scanning was performed with a pitch of 2.2 mm. Test object was located on the table of scanning device, while hidden embeddings were positioned at different angles in respect of orthogonal transceiver pair of module. Following amplification and digitization, valid signak was supplied at the input of personal computer.

Fig. 1 shows radio-image of embeddings covered with layer of optically nontransparent dielectric inhomogeneous material of 10 mm thickness.

Subsequent computer processing will make it possible to obtain image close to photographic one.

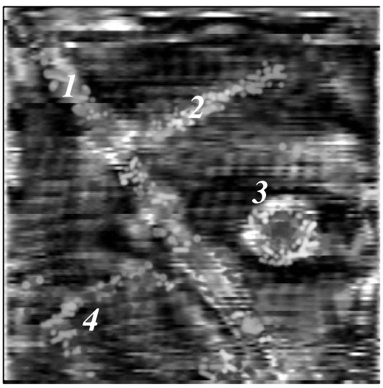

Fig. 1. Metal and non-metal objects of various shapes were used as embeddings:
1 – metal rule, *2* – ceramic plate, *3* – metal ring, *4* – dielectric frame (of hardened paper)

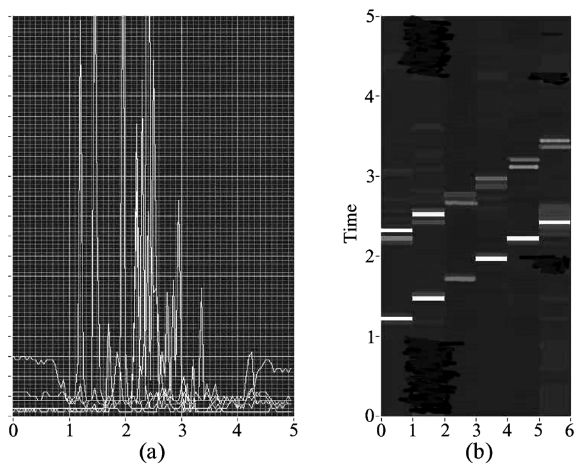

Fig. 2. Oscillograms of variation of valid signal amplitudes in the channels of receiving detectors line (left); **traces of extended embeddingts below the plaster-board layer** (right): (a) – is fiber-optic bundle; (b) – two thin conductors spaced by the distance of 10 mm

In order to reduce time to obtain radio-image, the line of receiving detectors based on the Schottky-barrier diodes was used. It is prospective for detection of extended objects. In this case, it becomes sufficient to record only the trace of an object without plotting its image. As an example, Fig. 2 shows image of embeddings in the form of extended conductive and non-conductive lines in the medium of enclosing construction materials. Thin conductor in insulation was used as a conductive line, while channel with optic fiber – as a non-conductive one. Following construction materials were used: plasterboard, light concrete, ceramics, bricks, etc.

Analysis of results of experimental studies demonstrates possibility of creation of portable equipment for detection and identification of various prohibited items concealed in the surface layers of enclosing construction materials, under clothes or in shoes of passengers.

It becomes feasible practically to create non-cooled receiving arrays through integration of existed receiving lines of detectors with small pitch between diodes by means of nanotechnologies.

References:

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