The Multicomponent Composition of the Low Acoustic Impedance Matching Layer for the Ultrasonic Transducer Operating in the Air

Tadeusz Gudra

Institute of Telecommunication and Acoustics, Wroclaw University of Technology, Wybrzeze Wyspianskiego 27, 50-370 Wroclaw, Poland

Abstract: The paper presents a new material composition of low acoustic impedance named ITAKOM®, whose acoustic characteristics makes it applicable as a matching layer medium between a piezoceramic transducer and a gas medium in a wide range of frequency. This composition, due to applied components, enables the obtaining of an acoustic impedance in a range \((0.2 \pm 1) \times 10^6 \, \text{kg/(m}^2\text{s})\).

INTRODUCTION

To generate ultrasonic waves in the air within the frequency range above 100 kHz we use electrostatic transducers radiating energy directly to the air or piezoceramic transducers radiating energy through intermediary layers with proper acoustic parameters ensured by matching a high acoustic impedance of piezoelectric ceramic with the low impedance of the air. The selection criteria of these layers can be different depending on the assumed transducer equivalent circuit or assumed transmission parameters, but a low acoustic impedance is the common feature of these layers.

In the paper a new material composition, whose acoustic characteristics makes it applicable as a matching layer between a piezoelectric transducer and a gas medium is presented. The properties of this material can be compared to other materials of low acoustic impedance (1,2,3).

MATERIAL COMPONENTS

The analysis of acoustic parameters of different natural materials shows that balsa wood \((Z = 0.57 \times 10^6 \, \text{kg/(m}^2\text{s})\) and carbon \((Z = 0.77 \times 10^6 \, \text{kg/(m}^2\text{s})\) are characterized by the lowest value of acoustic impedance. These materials because of high attenuation and little strenght, cannot be applied directly for matching layers. The lowest value of acoustic impedance can be obtained thanks the application of a multicomponent composition of different materials. This composition can be made up e.g. from minerals characterized by cristal structure with high quantities of free spaces, forming a system of open channels or closed spaces filled with gas.

Porosity is a common feature of all the lowest acoustic impedance materials, both natural as well as manufactured. It is necessary to notice that the porosity of the material used in the production of matching layers does not determine its usefulness for this purpose. For example, pumice is a very popular porous material of irregular pores of a diameter about 150 \( \mu \text{m} \) and after its powdering it can be seen that pores make about 85\% of its volume. In polyolefin (3) pores make about 70\% of the volume and their diameter is about 0.2 \( \mu \text{m} \). Although the percentage of pores in both materials is comparable, the transmission properties of polyolefin are decidedly better. The experimental investigation of different material compositions shows that pores diameters and their percentage have greater importance than the composite make-up.

In the construction of multicomponent materials the substantial part is played by the substances joining particular components.

Depending on the strength requirements resulting from applications (e.g. the kind of transducer functioning) we can use different glues like epoxy resins or polymer adhesives. It is desirable to obtain, during hardening or polymerisation, formation additional closed microspaces filled with gas, which lower the density of the composite and thus lower its acoustic impedance.
ACOUSTIC PROPERTIES OF ITAKOM®

Basing on the assumptions presented above a new composite material named ITAKOM® has been elaborated. ITAKOM® is a multicomponent amorphous compositions in which glass gas-filled balloons of 10µm ÷ 180µm diameter have been used as one of the components. These balloons are joined by a binding agent. The use of additional low acoustic impedance components as fillers in the binding agent reduces its acoustic impedance. Of course, both the application of glass balloons of the smallest diameter and the application of binding agent with additional closed gas-filled microspaces formed during hardening are desirable.

The comparatively wide range of density (ρ = 250 ÷ 500 kg/m³) and of wave velocity (c = 910 ÷ 1980m/s) makes it possible to obtain materials of acoustic impedance ranging (0.2 ÷ 1)·10⁶ kg/(m² s). Attenuation coefficient of ITAKOM® depends on the percentage of particular components. For example of acoustic impedance Z = 0.95·10⁶ kg/(m² s), the attenuation coefficient measured at frequency 1MHz is about 6dB/mm.

EXPERIMENTAL RESULTS

The elaborated multicomponent material has been applied as a matching layer in flat and focusing transducer working within a frequency range 200 kHz ÷ 1.5 MHz. The examples of signals obtained in transmission mode in the air are presented in Fig.1.

![FIGURE 1](image)

**FIGURE 1.** Impulse from the receiving transducer located in a 20mm distance from the transmitter excited by burst (a) U=20 V, f=212.5 kHz, number of periods n=40, (b) U=6 V, f=1.27 MHz, number of periods n=30.

An example of the application of this material to construct a focusing transducer operating in the air at the frequency of f=1.27 MHz in the set-up of scanning acoustic microscopy as well as the results of object measurements are presented in the paper (5).

CONCLUSIONS

ITAKOM®, a new low acoustic impedance composite, has acoustic parameters appropriate for using it as a matching layer between a piezoceramic transducer and a gas medium. A relatively simple technology of production, and the possibility to obtain required values of acoustic impedance make this material applicable in piezoceramic transducer working in the air with one or more matching layers.

REFERENCES