Diffusion of Sound Waves by Sonic Crystals

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Introduction

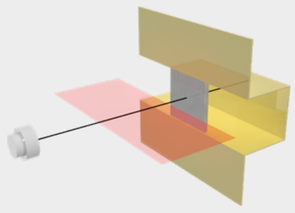
In this work we report an experimental study on the reflection and diffusion properties [1, 2] of sound by sonic crystals. Crystals with different lattice symmetries and filling factions have been built in titanium by 3D laser-based printing. We use an ultrasonic transducer as a source, and the field scattered by the structure immersed in a water tank was measured in the half-space of the source. Far field are obtained from the measurements, evidencing the influence on the crystal parameters on the directivity of the reflected field. This study has been done in the context of a project with the European Space Agency (ESA) entitle "Sonic Crystal for noise reduction at the launchpad".

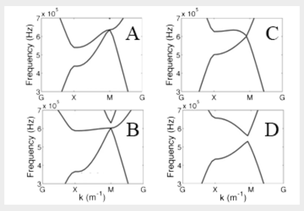


Experimental Setup

Specifically, we present results of four Sonic Crystals (SC) made of square rod scatterers. In two cases the scatterers are placed forming a **squared** lattice with **low filling fraction** (A) and **high filling fraction** (B), and, in the other two cases, are placed forming a **triangular** lattice, also with low/ high filling fraction (C and D, respectively).



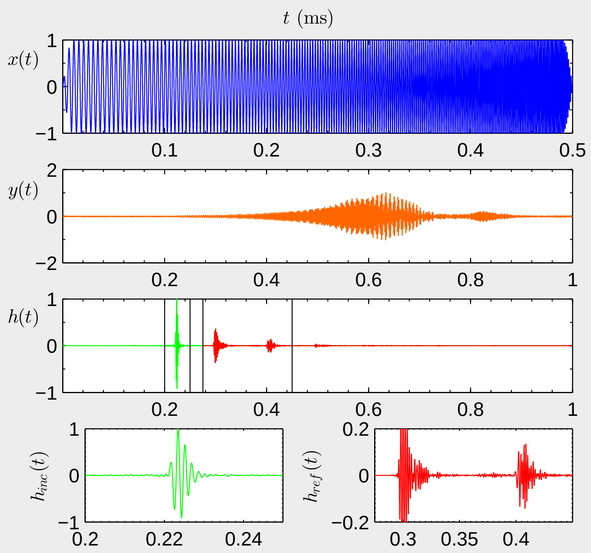




In order to approximate the real configuration of the ESA launchpad, we made a metallic channel which acts as a resonant open cavity like in the real case. The studied configurations consist of putting a sonic crystal in the entrance of the open cavity witch interacts with the incident wave and with the transmitted through the crystal that is reflected in the cavity bottom.

Impulse Response h(t)

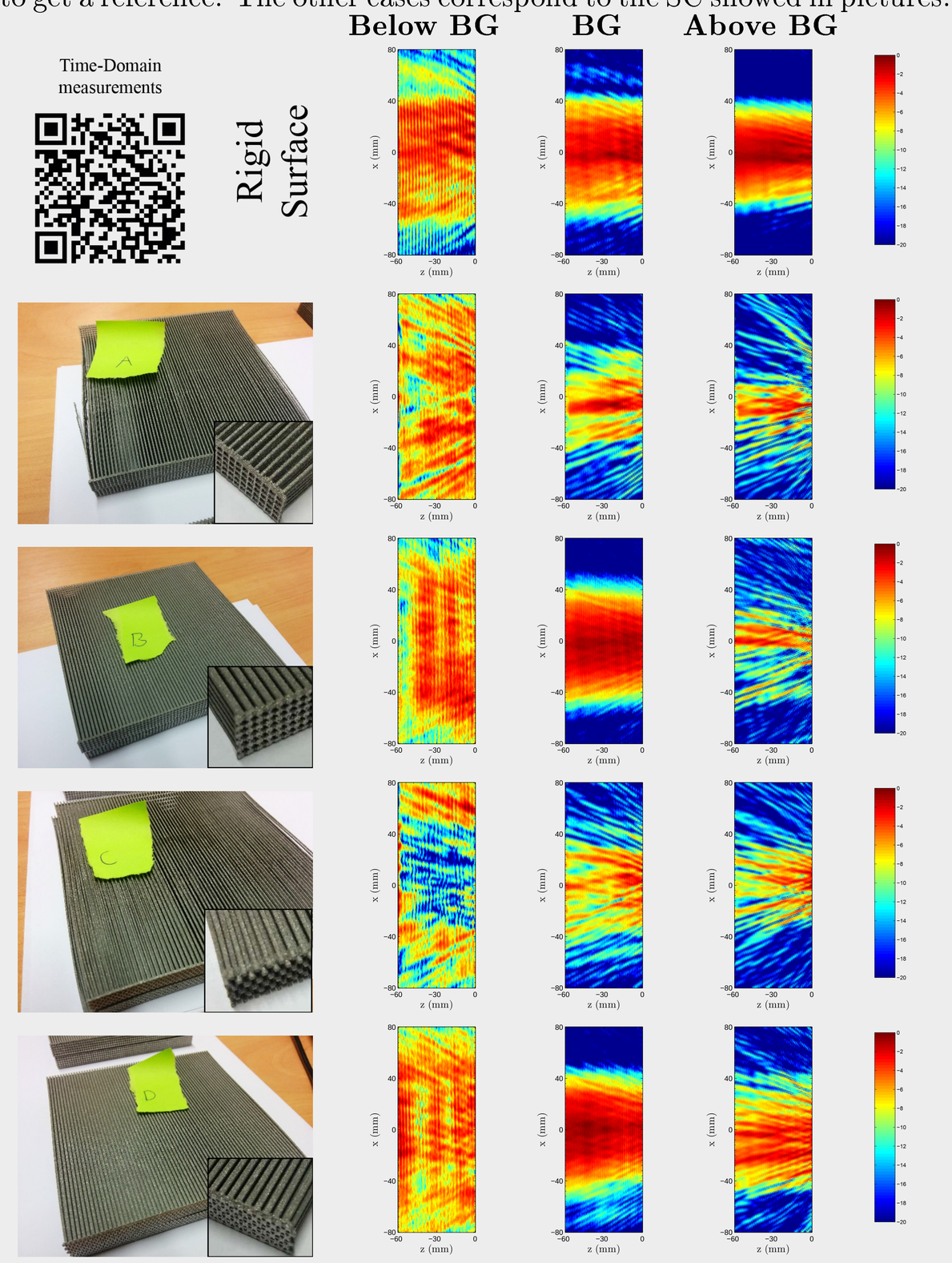
Giving a signal $x(t)$ as input of a LTI system that gives a response $y(t)$, this system can be fully characterized by its impulse response (IR)($h(t)$): $y(t) = x(t) \otimes h(t)$. This signal can be obtained via deconvolving the response with the inverse filter of $x(t)$. For this experiment we have chosen an exponentially-sweep sine as input signal as in [3].



In this figure, we can see the injected signal ($x(t)$), the measured response of the system ($y(t)$) for that input signal, the impulse response of the system ($h(t)$) obtained by deconvolution. Finally, we can see two insets of the IR response, the incident part ($h_{inc}(t)$) and the reflected one ($h_{ref}(t)$).
This method allows us to separate **incident** and **reflected** contribution and get a **broadband** response with just one measure per point.

Results

Reflected field by different configurations for frequencies 350 kHz (below the Band Gap), 500 kHz (in the Band Gap) and 660 kHz (above the Band Gap). The field has been measured in an horizontal plane normal to the crystal (see experimental setup). It is located in the coordinate $x = 20$ mm with respect to the origin. In the first row, we present the measurement corresponding to a rigid surface with the same size of the crystals in order to get a reference. The other cases correspond to the SC showed in pictures.



The maps above show that the reflected field strongly depends on frequency. In the band gap, the reflection is very similar to the corresponding to the rigid surface, i.e., they present an specular behaviour. Finally, above the band gap we can appreciate that the diffraction predominates.

Far Field for Crystal-A:



Bibliography

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