Acoustic metamaterials
with complicated material behavior

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This talk addresses the wave characteristics of acoustic metamaterials with the local resonance effect capable of manipulating with elastic waves in a low-frequency range. We investigate the dispersion of waves propagating in periodic composite made of rubber-covered lead cylinders embedded in epoxy. The band diagrams (with pass and subwavelength stop bands) for this composite have been studied by many researchers under assumption on linear elastic behavior of the constituents. However, the reported elastic moduli for rubber are extremely low and beyond any physically meaningful values in polymer science. In our study, the recently measured correct moduli for rubber are used, and their influence on the band diagrams is analyzed in detail. First, we construct an analytical solution to evaluate the lower bound of stop bands of any order. Then, we study the dependence of the stop band frequencies on geometric and topological parameters of the metamaterial, and propose an advanced design to increase the stop band size. The next step is the analysis of the viscoelastic damping (inherently present in the polymers such as epoxy and rubber) on the wave dispersion in the mentioned metamaterial. To that purpose, we adapt the finite-element based $\mathbf{k}(\omega)$-approach, which is recently used in the wave dispersion analysis of viscoelastic phononic crystals. The study is

performed for real-valued frequencies and complex-valued wavenumbers of waves representing the spatial wave decay that facilitates possible experimental validation of the obtained results. The complete 3D dispersion diagrams are calculated, and detailed analysis of the viscoelastic effect on the wave dispersion is discussed. Finally, brief remarks of the sufficiency of the Brillouin zone's borders for the evaluation of the stop band bounds are presented, and further research directions are mentioned.

Anastasiia Krushynska received the B.Sc. and M.Sc. degrees in Applied Mathematics from Donetsk National University, Ukraine, in 2004 and 2005, respectively, and the Ph.D. degree in Mechanics of Deformable Solids from Kyiv National Taras Shevchenko University, Ukraine, in 2008. Her Ph.D. study is devoted to theoretical modelling of guided waves in elastic waveguides of complicated geometry with applications to NDE techniques. During her Ph.D. project, she was involved into collaboration with National Taiwan University on theoretical and experimental analysis of electro-mechanical vibrations of piezoelectric resonators. From 2008 to 2010, she worked as a research fellow on various problems of guided waves in elastic waveguides. From 2010 to 2011, she worked as an independent researcher by studying edge waves in elastic wedges and modeling vibrational piezoelectric gyroscopes. Since 2013 until now, she works as a postdoctoral fellow at the Department of Mechanical Engineering, Eindhoven University of Technology, the Netherlands by carrying out the multi-scale modeling and dispersion analysis of acoustic metamaterials with local resonances. Her research interests are in the field of guided and surface waves in elastic solids, vibration analysis, piezoelectric theory, and acoustic metamaterials. In these areas, she has published about 20 peer-reviewed papers, including 1 review. She is a member of different societies for mechanical engineers and a reviewer of 2 journals.