Metamaterial as a tool for temperature measurement

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Metamaterials are well-known engineering materials characterized by negative effective mechanical properties, resulting in intriguing phenomena like negative group velocity, Dirac points, and bandgaps. Among these features, the bandgap is the most widely studied, particularly for its applications as a mechanical filter and the efforts to expand its size. Most research in this area has been conducted at room temperature. However, since material properties are temperature-dependent, the bandgap configuration varies with temperature. Therefore, it is crucial to associate specific temperature values with precise bandgap configurations. This research presents an exploration of the bandgap configuration for both SH (Shear-Horizontal) and Lamb waves propagating through a phononic crystal with a simple design involving surface-bonded pillars on a plate. Different materials are used for the pillars to investigate the influence of thermal strain on the bandgap configuration. Dispersion curves were calculated over a temperature range from 20°C to 500°C. As temperature increases, higher modes of both Lamb and SH waves tend to exhibit lower frequencies. It can be concluded that the first modes of Lamb and SH waves are less sensitive to temperature variations compared to the higher modes. When the material of the pillars is changed from copper to ceramic, which has a lower coefficient of thermal expansion, the second bandgap shows increased sensitivity to temperature variations. Overall, these results highlight the potential of metamaterials for applications in temperature sensing.