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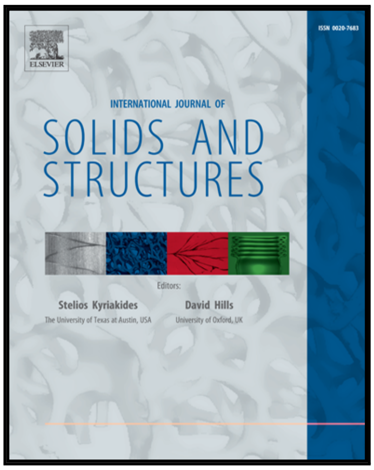


# Voltage-controlled complete stopbands in two-dimensional soft dielectrics

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# Voltage-controlled complete stopbands in two-dimensional soft dielectrics

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**Abstract**

Dielectric elastomers deform and stiffen when subjected to voltage. This work demonstrates how fiber composites made of incompressible dielectric elastomers exhibit *complete* band gaps—frequency ranges in which elastic wave propagation is prohibited, irrespective of its *polarization and direction*. To this end, we first analytically determine the quasi-static response of a wide class of composites to an electric field along the fibers. We then formulate and calculate incremental motions of general polarization propagating in the deformed composite, using a plane wave expansion approach. We numerically explore the dependency of the motion on the composite properties and electric field. We show how *complete* band gaps are tuned by adjusting the electric field, owing to resultant geometrical and physical changes. These results suggest that soft dielectrics can serve as tunable waveguides and filters.

*Keywords*: Dielectric elastomer, Wave propagation, Band gap, Composite, Phononic crystal, Plane wave expansion, Nonlinear elasticity

## 1 Introduction

The frequency spectrum of periodic media exhibits bands, termed *band gaps* or *stopbands*, in which waves are forbidden from propagating. *Bragg* band gaps result from the multiple scattering and subsequent interference of incoming and refracted waves. When the periodic medium is elastic, this unusual phenomenon corresponds to the decay of mechanical motions (Kushwaha et al., 1993). Accordingly, elastic band gaps can be employed to suppress noise (Shen et al., 2015), isolate undesired vibrations (Olhoff et al., 2012), or conversely guide waves (Laude et al., 2005). To recall just a few of the relevant experiments, we refer to Garcia-Pablos et al. (2000), Vasseur et al. (2001), Wen et al. (2005), Schneider et al. (2012) and Celli and Gonella (2015).

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