櫛形電極を用いたGaAsバレーフォノニック結晶エッジ状態のオンチップ励起に関する検討

Investigation of on-chip excitation of edge-states in GaAs valley phononic crystals by using interdigital electrodes

東大生研 [1], 東大先端研 [2], 東大ナノ量子機構 [3] ○(M2)孫 照印 [1,2], 金 仁基 [1,2], 岩本 敏 [1,2,3]

IIS [1], RCAST[2], NanoQuine[3], Univ. of Tokyo, °Z. Sun[1,2], I. Kim[1,2], S. Iwamoto[1,2,3]

E-mail: sunzy@iis.u-tokyo.ac.jp

Valley phononic crystals (VPnCs), which enable elastic waves to propagate robustly, have attracted much attention in recent years [1]. In particular, VPnCs at the gigahertz range are expected to be useful in various applications including on-chip high-speed signal processing. We have previously reported a design of GaAs-based VPnC and numerically demonstrated the efficient guiding of GHz elastic waves using the topological edge states [2]. For real applications, it is also important to develop a scheme for exciting the edge state on-chip. Piezoelectricity of GaAs can be used for the purpose. Here we numerically demonstrate that the edge state of GaAs VPnC can be excited on chip by using an interdigital transducer (IDT).

Figure 1(a) shows a schematic of the structure we considered. The VPnC in a 310-nm-thick GaAs slab is designed based on the previous work [2]. It has an interface formed by two topologically distinct structures and supports an edge state at around 2.6 GHz. The main interface is formed along the GaAs crystallographic axis of [100] as shown in Fig. 1 (a). On the surface of the same slab, metallic interdigital electrodes forming an IDT are deposited. The IDT is designed with a curved shape in order to focus the elastic energy at the edge of the VPnC. This allows the electrically-driven elastic waves to couple with the edge state efficiently. The IDT period *p* defined in Fig. 1 (a) is set to 1.8 μm so that the IDT can generate the elastic wave at 2.6 GHz. The width of each electrode and the distance between two neighboring electrodes are *p*/4. We simulated the electrical excitation of elastic wave and its propagation based on finite element method (FEM) using COMSOL Multiphysics software. Figure 1(b) shows a distribution of the total displacement in the VPnC when the IDT is driven. The result clearly indicates that the edge state can be well excited by the elastic wave generated by the IDT monolithically integrated with the VPnC.

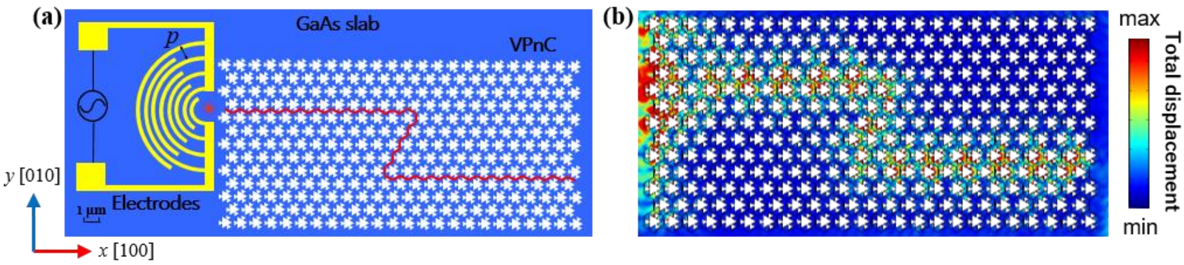

Fig. 1. (a) Schematic of the structure we investigated. An IDT and a VPnC are monolithically integrated on a same GaAs slab. (b) Total displacement induced by the IDT operating at 2.6GHz.

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References: [1] R. K. Palm, *et al*., New J. Phys. **19**, 025001 (2017). [2] I. Kim, *et al*., Appl. Phys. Express **12**, 047001 (2019).