Investigation of flat bands in bilayer one-dimensional moiré photonic crystals with staggered potential (II)

Keio Univ. [1], RCAST, the Univ. of Tokyo[2], ◦ S.M. Truhsin[1], Y. Ishii[1], T. Ito[1] and S. Iwamoto[2], Y. Ota[1]

E-mail: trushin.stepan@keio.jp

Moiré photonic crystals (PhCs) offer novel approaches to control over the flow of light and have shown intriguing phenomena including flat band light localization, which has been utilized for high Q factor nanocavities and nanolasers [1]. Bilayer one-dimensional (1D) PhCs are one of the simplest moiré photonic structures but have been a profound playground for studying high-Q cavity formation in flat bands [2]. However, there has been less discussion on which factors determine Q factor of the localized modes. Previously, we reported flat band light localization in bilayer moiré structures formed by 1D PhCs with double periodic modulation [3]. In this contribution, we study the very similar bilayer moiré PhC and report that the relative lateral shift of the bilayer largely influences on the Q-factor of a flat-band localized mode.

The investigated structure (Fig. 1(a)) is formed by two 1D Si photonic slabs with N and N+1 unit cells with mismatched periods of a_1 and a_2. Each unit cell (Fig. 1(b)) consists of two rods with widths of f_1a_i and f_2a_i, where $f_2a_i \neq f_1a_i$ (i=1,2). We investigated two configurations of the moiré PhCs with different relative shifts Δs in the unit cells defined in Fig. 1(c) and (d). We numerically analyzed the two structures by the finite element method. First, we studied the response of a moiré flat band to the variation of interlayer distance L. As seen in the upper panel of Fig. 1(e), the two curves behave similarly but the positions of the magic distances are modified. Next, we studied the impact of Δ on Q factor, as summarizes in the lower panel of Fig. 1(e). As L decreases, the Q factor of the flat band mode designed with $\Delta = f_1a_i/4$ (Δ=0) increases (decreases), with the maximum value of 1.8×10^3 (minimum of 300) at L=0, resulting in the difference of the Q factors by a factor of more than 6.

Acknowledgment: This work was supported by KAKENHI (22H00298, 22H01994, 22K18989), JST CREST(JPMJCR19T1) and JST FOREST Program (JPMJFR213F).

References: [1] X. R. Mao, *et al.*, Nat. Nanotechnol. 16, 1099 (2021). [2] S. Chirine, *et al.*, Optica 11, 245-250 (2024). [3] S. M. Trushin, *et. al.*, JSAP Spring, 24a-11E-1 (2024).

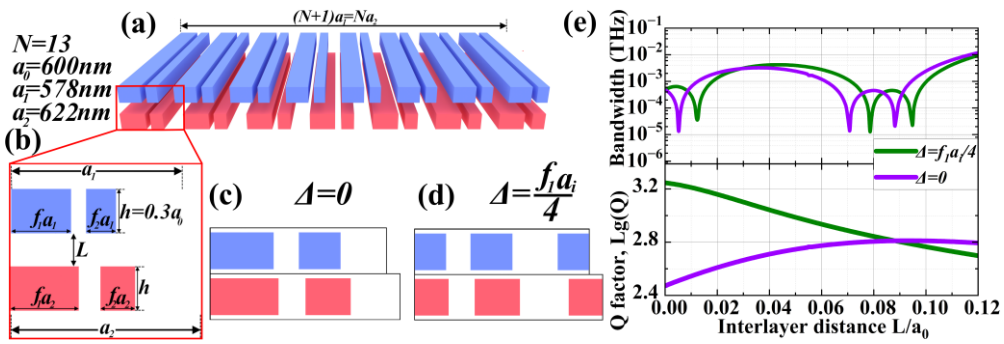

Figure 1. (a) Investigated structure. (b) Respective unit cells of the PhC bilayer. (c) First unit cells for the moiré PhC with Δ=0 and (d) for the case with the unit cells respectively shifted by $\Delta = f_ia_i/4$. (e) Bandwidth of the flat band mode investigated. (f) Q-factor as the function of L. a_0 is $a_0=(a_1+a_2)/2$.