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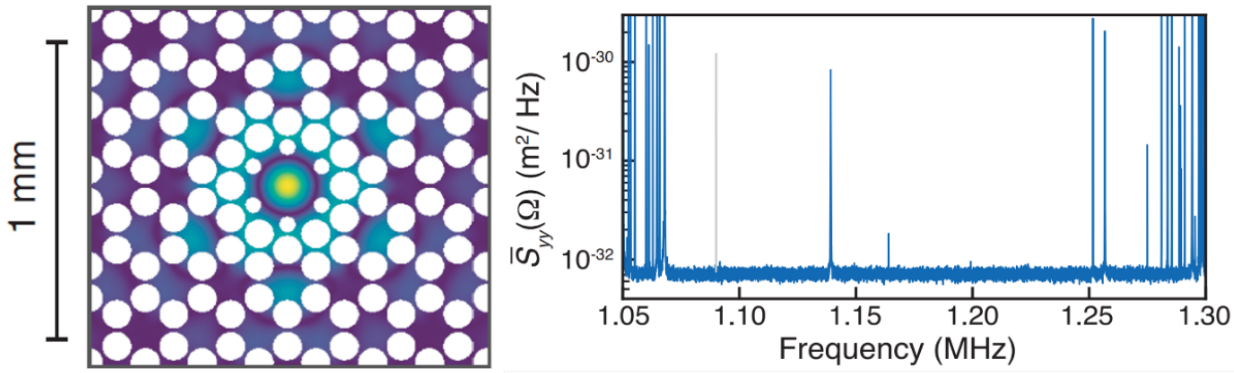
info@qfactory.dk

Dahlia Membrane Resonators

Ultrahigh Q-factor, Soft-Clamped Mechanics with Phononic Crystal Isolation

Dahlia-Class resonators are the original phononic membrane resonator design first introduced in 2017 [1], and have since been utilized to achieve milestones in quantum optomechanics [2,3,4]. They are user-friendly due to a relatively large central defect, while maintaining ultrahigh quality factors through soft-clamping. They possess five spatially localized mechanical modes in the bandgap. The primary mechanical mode is spectrally isolated from the other defect modes and the edge of the bandgap (see below).



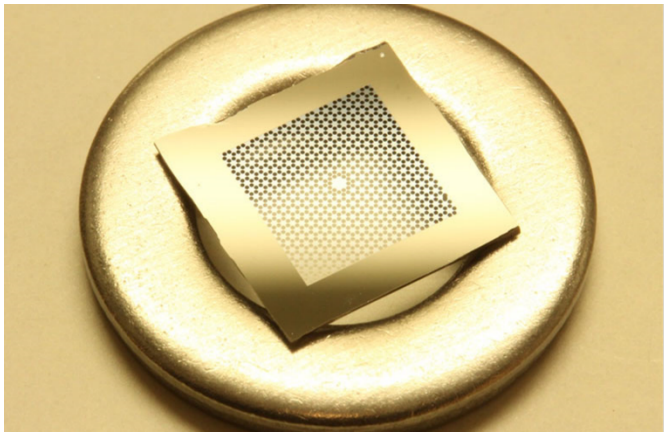
Sample mode profile and spectrum from [4], highlighting an isolated mode at 1.14 MHz.

Sources:

[1] Tsaturyan et al., Nature Nanotechnology 12, 776 (2017).
[2] Rossi et al., Nature 563, 53 (2018).
[3] Mason et al., Nature Physics 15, 745 (2019).
[4] Chen et al., Nature Communications 11, 943 (2020).

Offered Device Parameters

Dahlia-class resonators are offered over a range of parameters, determined by the (1) thickness of the Si3N4 layer (2) the scaling of the structure, and (3) configuration: A or B, which have different geometric parameters for the phononic crystal and defect. Configuration A was the design used in [2-4]. Configuration B has been tested and shown to have yet higher Q-factors at the expense of a larger effective mass.



Parameter	Unit	Scaling	Available range	Config A (example)	Config B (example)
Chip Size	mm	S	10, 15	10	15
Membrane Thickness	nm	h	30, 50, 100	100	30
Crystal Lattice Constant	µm	a	40 - 350	211	350
Primary Mech. Frequency	MHz	$f_0 \sim 1/a$	0.7 - 6.0	1.14	0.77
Bandgap Lower Limit	MHz	$\sim 1/a$	$(0.94\text{-}0.98) f_0$	1.07	0.75
Bandgap Upper Limit	MHz	$\sim 1/a$	$(1.11\text{-}1.14) f_0$	1.29	0.85
Defect Size	µm	$\sim a$	50 - 420	230	420
Total Membrane Size	mm	$\sim a$	0.75 - 10	3.9	6.6
Mode Mass	ng	$\sim a^2 \cdot h$	0.5 - 70	14.2	20.0
Quality Factor*	-	$\sim a^2/h$	$(5 - 160) \times 10^6$	22×10^6	160×10^6

* Typically obtained quality factor. Quality factors can be guaranteed through in-house measurements at a surcharge.

For any questions, concerns, or curiosities:

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