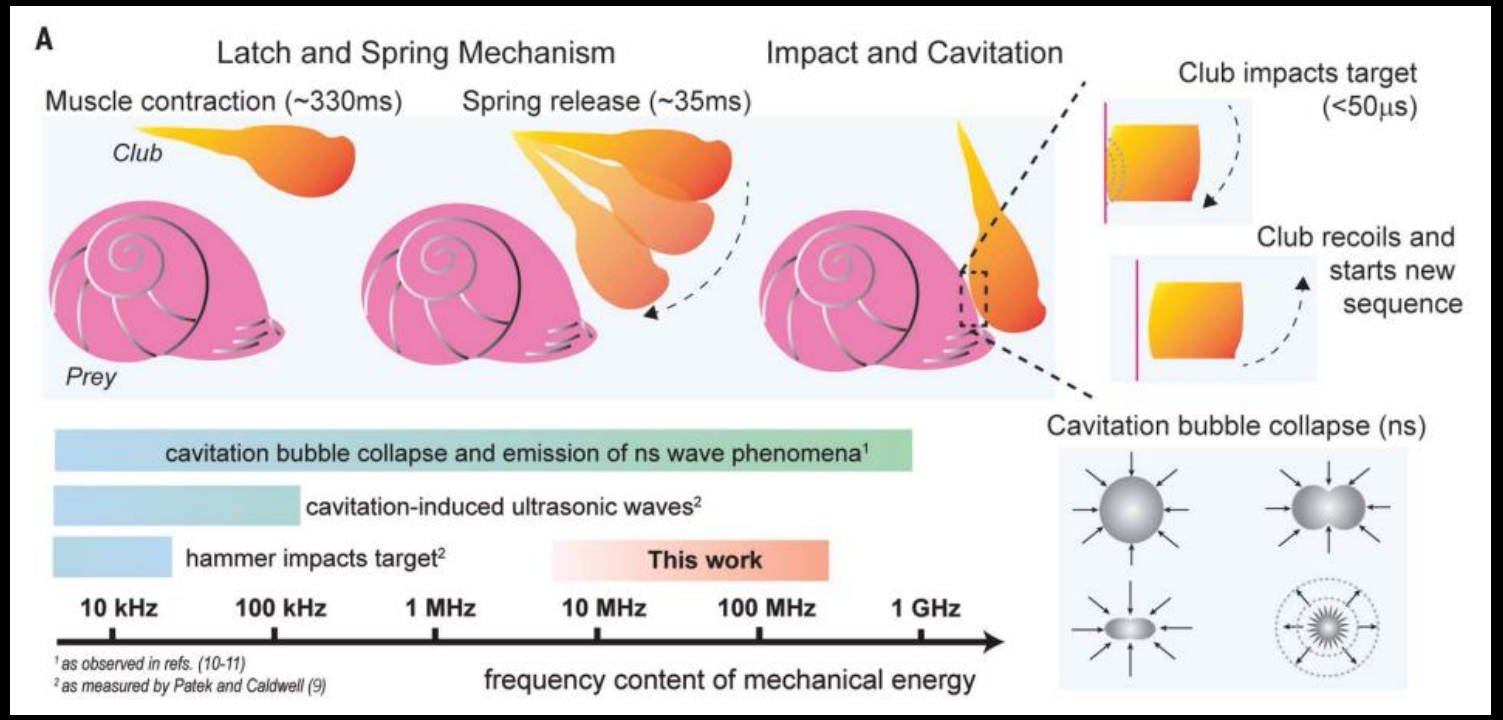
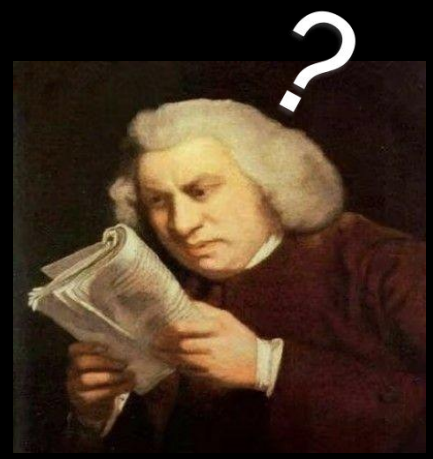
Does the mantis shrimp pack a phononic shield?

2025.9.12 YiqingYang



peak forces in the vicinity of ~1500 N (i.e., exceeding 1000 times its body weight)



雀尾螳螂虾，一拳出火花，你朋友能接住几下?

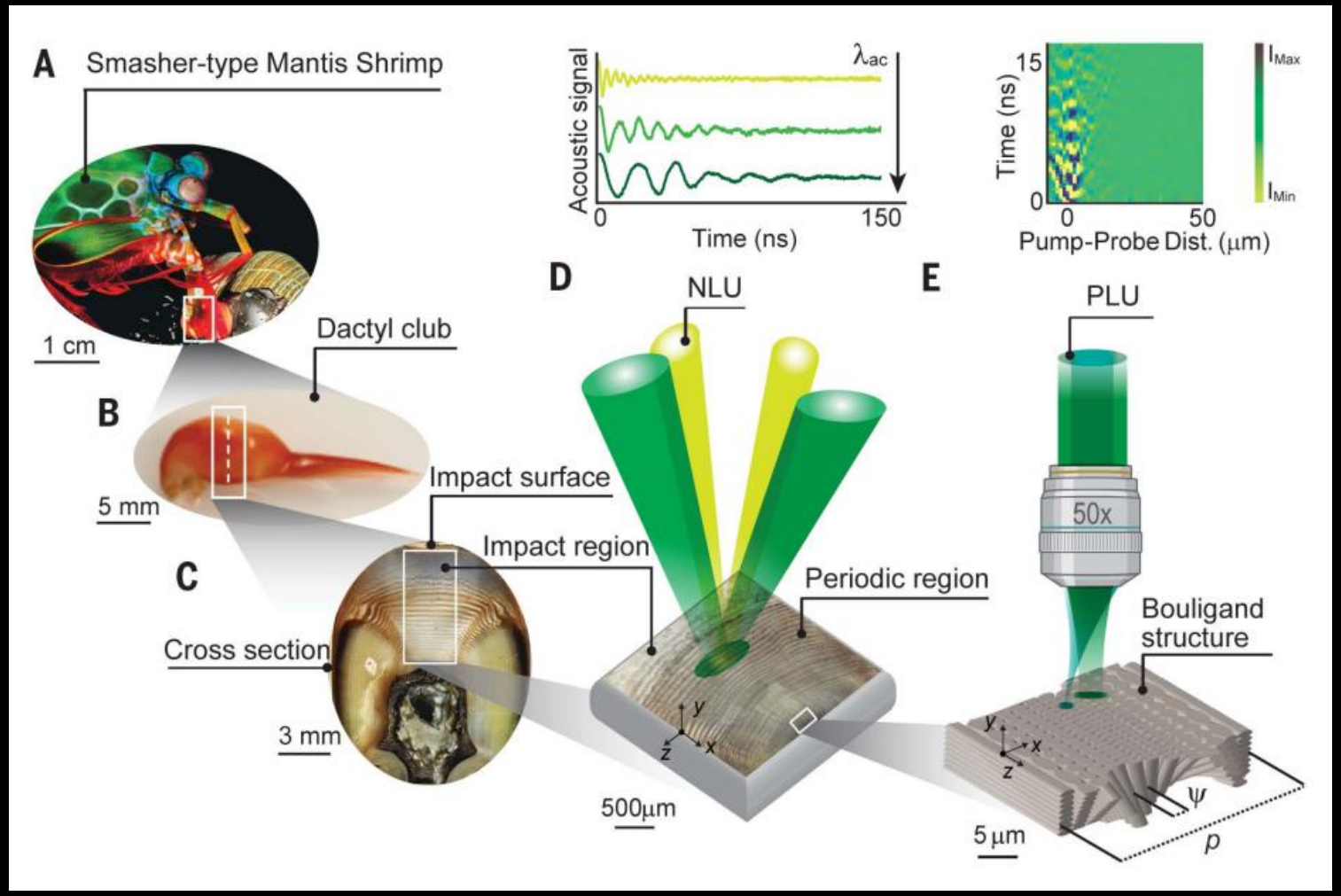
截图打开哔哩哔哩APP
立即观看完整视频

bilibili

What is phonon?

- A ***phonon*** is a quasiparticle, collective excitation in a ***periodic, elastic arrangement of atoms or molecules*** in condensed matter, specifically in solids and some liquids.

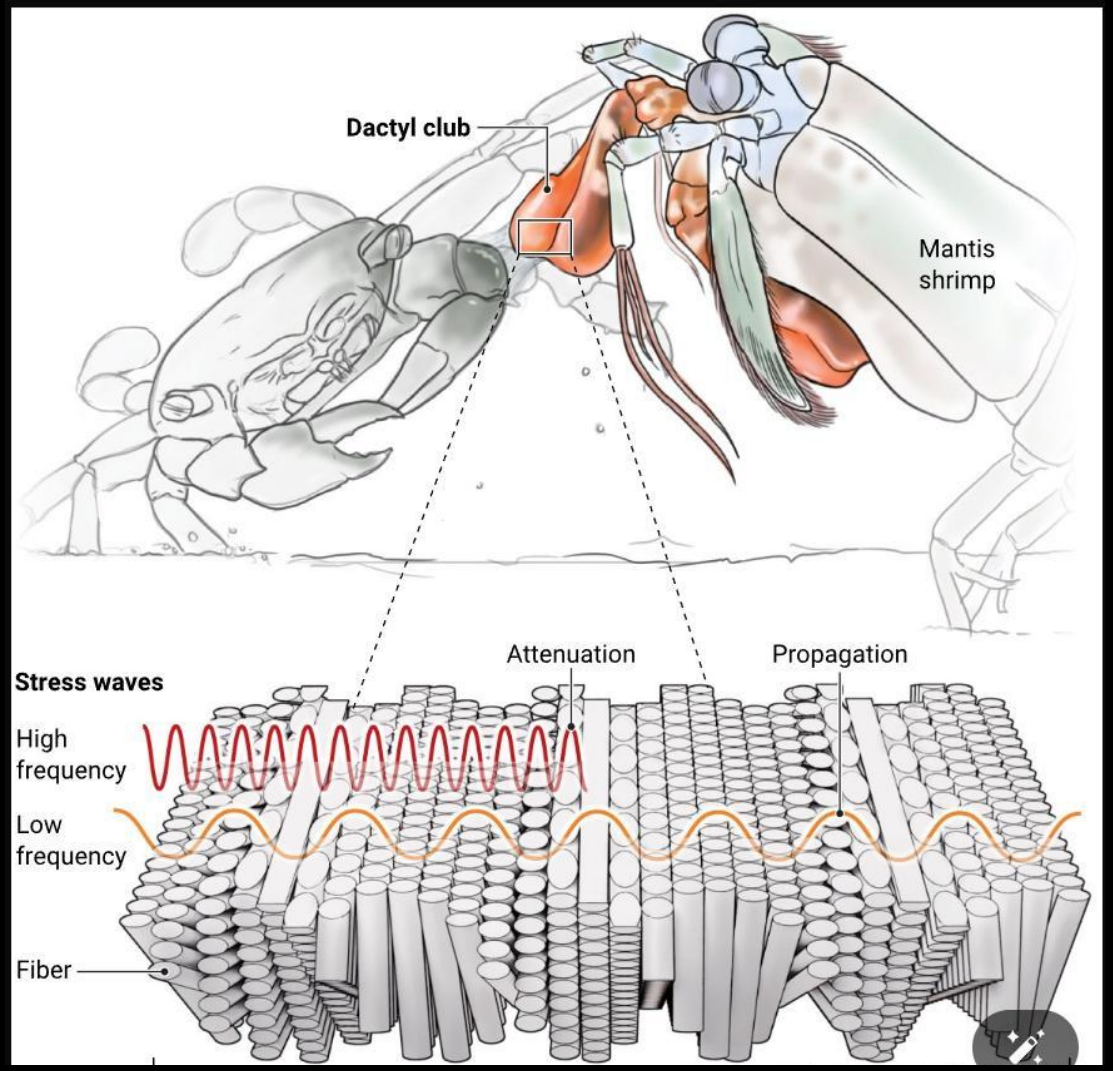
Experiments



NLU-纳秒泵探测激光超声

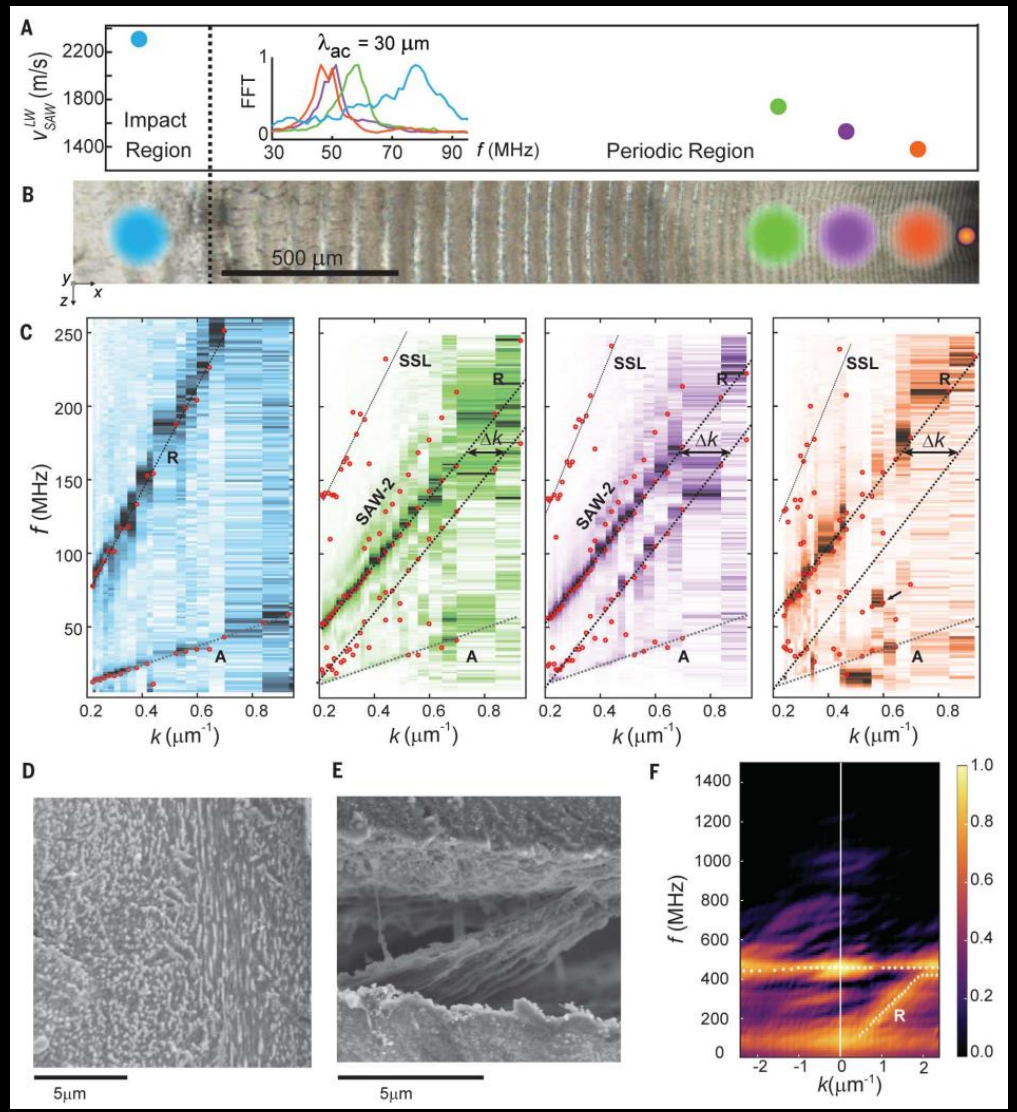
PLU-皮秒泵探测激光超声

Periodic region(closer look)



Bouligand structure

Experiments



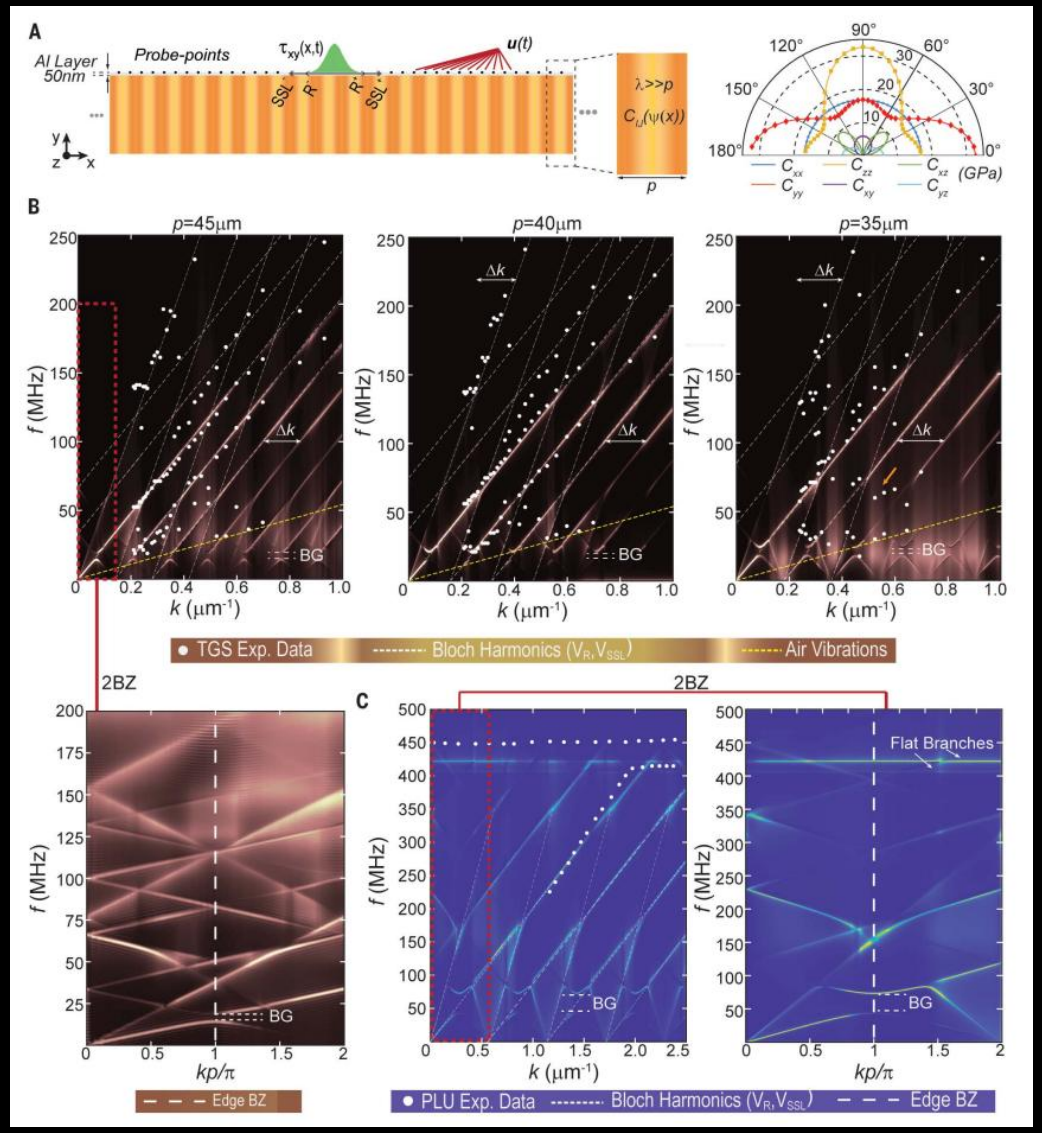
impact region

periodic region (p=45μm)

periodic region (p=40μm)

periodic region (p=35μm)

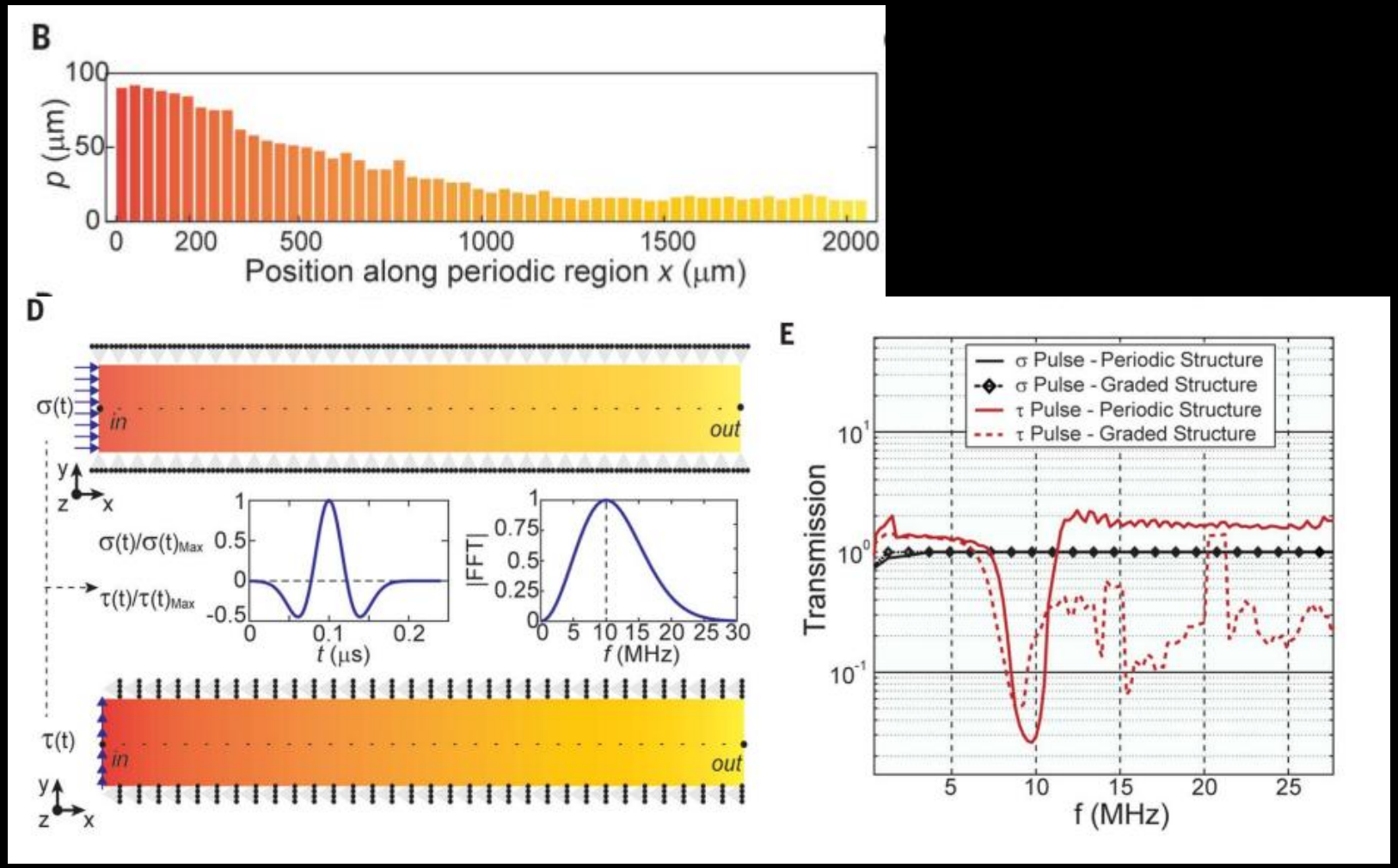
FEM analysis



The results from FEM analysis are consistent to the data collected through experiments (NLU & PLU)

Representing that the model is well constructed and can somehow predict real life situation

Function of graded periodic region



Wave transmission

Single-pitch structure – 66%

Graded structure – 43%

Summary

- This study, using nanosecond/picosecond laser ultrasonics and numerical simulations, shows that the mantis shrimp's dactyl club "periodic region" is a high-quality, graded phononic structure.

- Transmission measurements and simulations indicate it scarcely filters longitudinal waves but creates pronounced, pitch-graded bandgaps for shear waves (~66% of shear energy transmitted through a single-pitch structure versus only ~43% through the graded structure), thus selectively protecting soft tissues and neural synapses from damaging high-frequency shear vibrations.