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3D-Printed Flexible Wings With Metamaterial Functionalities

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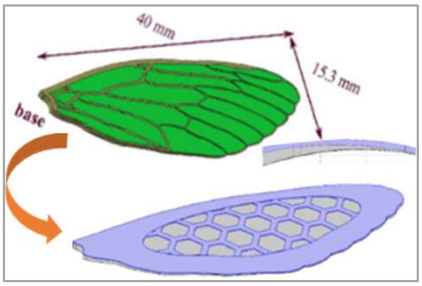
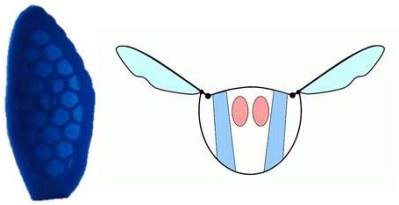
Design idea and analysis

www.metamechanics.net

Wing design and samples





Goals

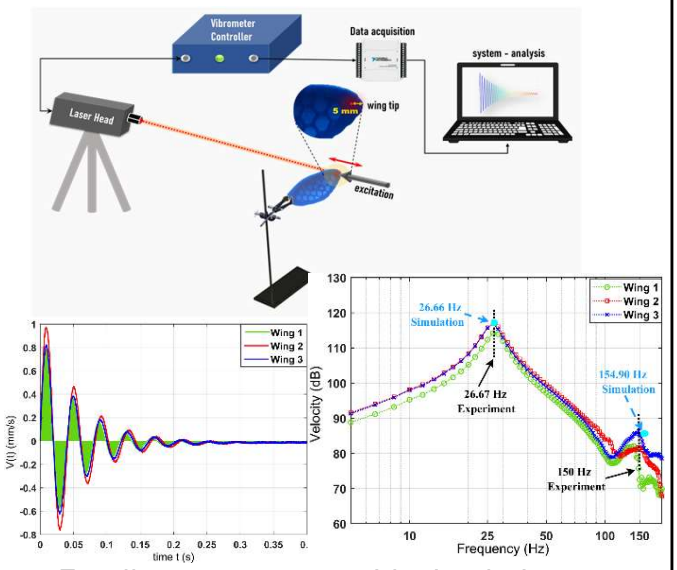
- Metamaterial pattern to control flight aerodynamics and acoustics
- Full-scale 3D modeling
- Explore possibilities of additive manufacturing and near-resonance flight conditions

Methods and material

- Honeycomb-patterned wing in a flapping flight
- Transient 3D FSI problem: FEM solution to coupled viscous incompressible Navier-Stokes equations for air and equations of motions for elastic wings under large deformations
- Commercial TPU – flexible, recycled, heat resistant

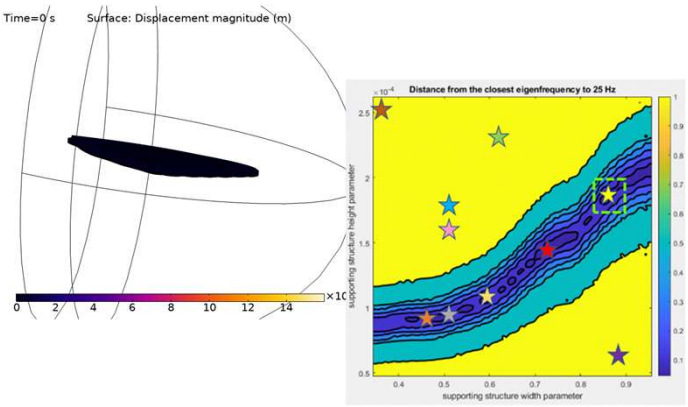
Results

Experimental testing



- Excellent agreement with simulations
- No damage under long-term resonance exc.

Numerical study and optimization



- Surface pattern can be used to increase lift and decrease generated sound
- Multi-parameter optimization is developed
- Anisotropic honeycombs are beneficial
- Near-resonance flight conditions enable to enhance lift up to 50%

References

- I. Zhilyaev, et.al., Bioinsp. Biomim. 17, 025002 (2022) https://doi.org/10.1088/1748-3190/ac42e2
- I. Zhilyaev, et. al., Materials & Design 218, 110709 (2022) https://doi.org/10.1016/j.matdes.2022.110709