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Editorial: Origami-inspired metamaterials and metastructures

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Editorial on the Research Topic
Editorial: Origami-inspired metamaterials and metastructures

Metamaterials and metasurfaces are artificial structures exhibiting various exotic properties that are rare in nature, which can provide a variety of appealing solutions for engineering problems, such as surfaces with changeable scattering and absorbing properties. One main advantage of such materials is the designable and reconfigurable properties associated with electromagnetic, optical, acoustic, thermal, and mechanical performances. These reconfigurable properties are facilitated through active material and/or geometric variations. The primary method to achieve geometric change is through translational and/or rotational deformation, while the latter provides higher nonlinearity, which happens to be the fundamental working principle of origami, i.e., folding of thin materials. Traditional origami can fold two-dimensional materials into complex three-dimensional ones, while origami-inspired designs extend the concept to bending-dominating objects which are most common in largely deformable materials containing thin components. This Research Topic gathers four peer-reviewed papers that address the challenges and opportunities in this field, focusing on the systematic design, actuation, and application of origami and kirigami-based metamaterials.

Reddy et al. investigates the kinematic behavior of tubular foldable mechanisms, focusing on the phenomenon of frustration propagation under geometric confinement. The authors employ a detailed theoretical and numerical analysis to understand how in-plane stretching and out-of-plane bending interact in these systems. The findings have significant implications for the design of reconfigurable metamaterials, where precise control over geometric states is crucial for achieving desired mechanical and functional properties.

Zhang et al. offers an insightful analysis of how variations in pre-folding angle and layer height impact the energy absorption efficiency of origami bellows. Through a combination of numerical and experimental methods, the authors demonstrate that graded bellows exhibit a controllable, progressive elongation with enhanced energy absorption, particularly when a large gradient in the pre-folding angle is applied. This work significantly advances the understanding of origami-inspired structures and their potential applications in energy absorption and adaptive systems.

Lin et al. introduces an innovative approach to controlling elastic wavefronts using reconfigurable zigzag-folded metasurfaces. The authors explore how varying the thickness and folding angles of these origami-inspired structures can dynamically modulate wave phases, enabling precise wavefront control for applications such as wave focusing and deflection. Their research, validated through both numerical models and experimental setups, highlights the versatility and potential of these metasurfaces in designing intelligent systems that can adapt to different environmental conditions. This work is a significant contribution to the field of elastic wave manipulation and opens new possibilities for reconfigurable metasurface designs.

Song et al. provides a comprehensive and insightful exploration of curved-crease origami, highlighting its unique mechanical properties and potential applications in fields ranging from aerospace to soft robotics. By meticulously reviewing the state-of-the-art in design methodologies, analytical methods, and practical implementations, the authors not only shed light on the complex interactions between crease folding and facet bending but also identify key challenges and future directions for the development of this fascinating area. This review serves as an invaluable resource for researchers and engineers, offering a thorough understanding of the capabilities and future possibilities of curved-crease origami in creating innovative, adaptable structures.

The papers featured in this Research Topic collectively represent a significant leap forward in the field of metamaterials and metasurfaces. They not only provide novel theoretical insights but also demonstrate practical applications that could revolutionize various industries, from aerospace to flexible electronics. The integration of origami-inspired designs into metamaterials is particularly promising, offering a pathway to highly adaptable, multifunctional systems that can meet the growing demands for reconfigurable and tunable materials. We look forward to seeing how these innovations will shape the next-generation of materials and structures, driving advancements that will resonate across multiple disciplines.

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