and sticky-end interactions. By tuning the binding strength, they were able to select a desired combination between stacking and short sticky-end interactions, and this was sufficiently strong to provide an optimal range of binding affinity to reverse spurious tile–tile interactions. Large Truchet patterns were achieved with single crystalline domains up to several micrometres.

Next, the researchers systematically demonstrated the programmability of their random-yet-controlled method. Varying internal patterns on the tiles created maze-like patterns with different branching rules (Fig. 1f). Adjusting the ratio of different types of tiles gave trees and loops with controlled dimensions (Fig. 1e). Programming the matching rules between the tiles allowed the creation of trees with different growing directions, branching properties and sizes (Fig. 1d). Grids with designed finite sizes were also realized, showing that their design principles could be used to scale up the assembly of finite DNA origami arrays. Furthermore, random mazes with designed entrances and exits were built, demonstrating the programmability of this method for controlling the configurations at specific locations.

A stochastic algorithm provides a simple solution for producing a wide variety of sophisticated arrays in a massively parallel fashion with a one-pot assembly process, but separating a single target pattern from a mixture remains challenging. One possible solution is to label and create responsive signal circuits with specific configurations that will facilitate the isolation of specific target patterns.

The creation of maze-like nanostructures with programmable disorder demonstrates the power of stochastic algorithmic self-assembly. By mimicking the complex environments inhabited by naturally existing molecular motors, mazes made of DNA origami nanostructures can provide a wide range of test conditions for DNA motors or walkers[10]. More importantly, the massively parallel production of complex nano-objects with programmable disorder could be combined with inorganic or biological functional materials to evolve molecular devices with novel functionalities that rival the biomolecular machineries in living systems. ❐

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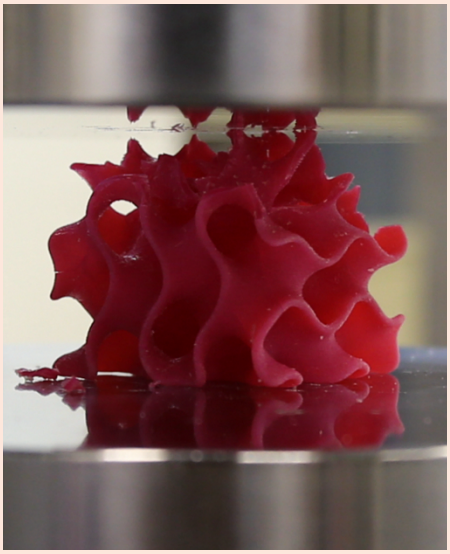
2D MATERIALS

Airborne graphene

Graphene is one of the best materials in terms of mechanical strength and stiffness; yet in its porous form, also known as graphene aerogel, it can become lighter than air, a property for which graphene has been proposed as a substitute for relatively rare and expensive helium. However, what makes graphene so special — its atomic thickness — often turns into a limiting factor as many applications rely on bulk materials properties. Extending the mechanical properties of graphene into the three-dimensional world is not straightforward. Fusing graphene flakes together into a bulk, for example, may quickly result in partial or complete loss of desired properties. To address this issue, Qin *et al.* have conducted a computational study with the aim of finding the optimal 3D graphene architecture with mechanical properties similar to those found in atomically thin graphene (*Sci. Adv.* **3,** 2375; 2017).

The process of gradual fusion of graphene flakes into a 3D assembly was reconstructed using a full atomic model. The resulting structures were built from graphene similar to that obtained via chemical vapour deposition growth. Because of the highly curved nature of graphene, the geometry of the resulting 3D assembly resembled a periodic gyroid.



AAAS

These modelled structures were then 3D-printed (pictured) and used to study the effect of scaling on the mechanical properties of graphene. Qin *et al.* found that the scaling laws are dominated by material architecture rather than the mechanics of graphene itself. Under optimized conditions, tensile strength can be one order of magnitude higher than that of steel. What's more, the simulations can predict the optimum aerogel density according to a specific mechanical requirement. The results of the study imply that optimally high mechanical strength and low total material usage for a graphene 3D aerogel can now be achieved in practice. However, the findings also suggest that these 3D structures made of curvy graphene flakes become too soft and weak with increasing density. Therefore, further optimization of the structural design is required for this lightweight material to regain the necessary strength to compete with state-of-the-art materials.

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