Not everyone who looks at red bell peppers immediately sees the solution to the manufacture of biocompatible, microrobotic gears, but SEAS associate professor Xi Chen did. Chen, who first explained why some fruits and vegetables have ridges, has applied these same buckling principles of engineering mechanics to the creation of small gears that can be used in surgical robots.

Today, creating gears requires a complicated and time-consuming lithography process, and the resulting pattern features are essentially two-dimensional. “Our breakthrough involves self-assembly created by mismatched deformation,” says Chen. “If we bond a thin film to a compliant cylinder substrate, upon relative shrinking of the substrate, the only way the system can handle the extra film surface is to buckle the film and form structures like teeth on a gear.”

This methodology can create three-dimensional biocompatible structures that are impossible to make with current lithography techniques. Chen and his team have shown they can predict the number and depth of the teeth, as well as create inclined and zigzag gears.

“Our goal is to find ways to manipulate patterns by playing with different geometrical and material parameters to force the substrate to make the pattern we want,” he says. “Our approach is quick, simple, and the cost is very low. We are now working to reduce the size of these gears to micrometer scale for use in surgical robots.”

Chen, who received his PhD and postdoctoral training at Harvard, received a Presidential Early Career Award for Scientists and Engineers (PECASE) last year for his outstanding research in mismatch damages in thin-film and nanoscale self-assembly.