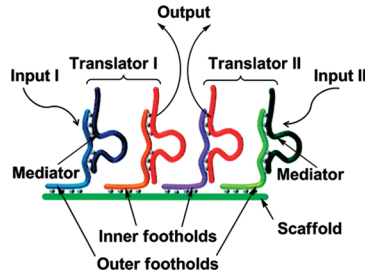
A Logical Design for DNA-Based Computation



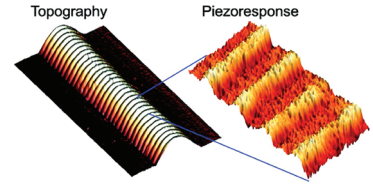
DNA has proven a useful structural component for a number of molecular devices, including those that perform information processing or programmed mechanical functions as a result of the application of external signals. Researcher teams have succeeded in developing simple computing devices, as well as a variety of DNA-based "machines" that perform programmed mechanical operations, such as walkers, tweezers, gears, and more. An ambitious aim is to combine the computational and mechanical functions of DNA-based devices to design modular and interconnected circuits.

In a step toward this goal, Shlyahovsky *et al.* (p 1831) designed a series of logic gates that perform "AND", "OR", and "XOR" functions using a DNA scaffold of four strands. Two of the DNA strands recognize input and are blocked by complementary nucleic acids, whereas the other two are output strands blocked by nucleic acids, including the horseradish peroxidase-mimicking DNAzyme sequence. Triggered by nucleic acid or low-molecular-weight inputs, the device releases output strands that result in the formation of products with differing absorption spectroscopy signals. Unlike previously designed DNA-based logic gates, input and output strands of these logic gates do not interact with each other, with inputs translating into mediator nucleic acid strands that affect the generation of the output strands. In addition to computing applications, the authors propose that this novel design might find application in future nanomedicine technology as DNA-translator-based devices. For example, such a device might eventually be designed to sense biomarkers for a certain disease, activating a translation process that releases predesigned nucleic acids that act either as antisense agents or as inhibitors for harmful enzymes.

Boning Up on Collagen's Piezoelectricity

Many biological materials—including bone, tendon, and dentin—display piezoelectricity, allowing them to generate an electrical charge in response to mechanical stress. Researchers have suggested that the origin of piezoelectricity in these materials could be individual collagen fibers of sizes below 100 nm; however, directly verifying this claim has been elusive since the effects from the collagen matrix composing these biological materials can be difficult to tease out.

Recently, Minary-Jolandan and Yu showed that a single isolated type I collagen fibril is predominantly a shear piezoelectric material. Extending these results in a new study (p 1859), the researchers probed electromechanical coupling properties of collagen at different relevant levels of hierarchy, from the subfibrillar structure of a single isolated collagen fibrial to the surface of a macroscopic-sized bone sample. Applying piezoresponse force microscopy to an individual type I collagen fibril less than 50 nm in diameter, the scientists show that the fibril is highly heterogeneous along its axial direction in its electromechanical property at the nanoscale, coinciding with the periodic variation of the fibril's gap and overlap regions. Their investigation of bone revealed that this heterogeneity persists in embedded collagen fibrils. The authors suggest that their findings may help explain the

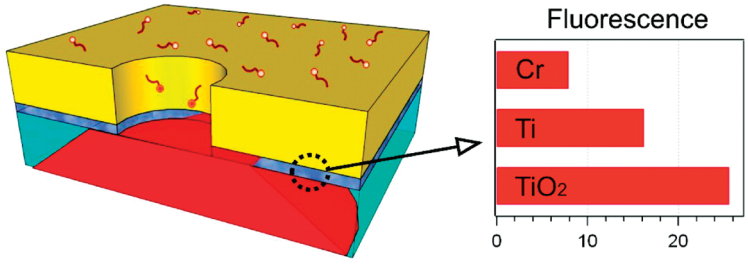


structural formation and remodeling of bone, with this piezoelectric heterogeneity leading to uneven distribution of electric charges in collagen fibrils under mechanical stimulation. Consequently, these charges may influence the local ionic environments as well as affect the binding affinities of the related biomolecules and ions responsible for bone growth and remodeling.

Plasmonic Nanoantennas: Tuning in on the Adhesion Layer

An increasing amount of attention has been focused on plasmonic nanoantennas for applications ranging from nanophotonics to enhanced light emission to molecular sensing. Since these components are typically fabricated from gold, they require an adhesion layer commonly fabricated from chromium or titanium to ensure firm contact between the gold film and the substrate. The influence of this adhesion layer in the performance of nanoantennas has not been well-characterized in previous studies. Consequently, whether a specific adhesion layer composition might improve or diminish performance was unknown.

Seeking to evaluate the influence of the adhesion layer on device performance, Aouani *et al.* (p 2043) took advantage of techniques they recently developed to characterize the fluorescence emission within single nanometer-sized apertures milled in gold films. In a new study, the team studied 120 nm apertures milled in a 200 nm thick gold film with several different adhesion layers: 5 nm of chromium or titanium, 10 nm of titanium, and 10 nm of titanium oxide (TiO_2) or chromium oxide (Cr_2O_3). Using a combination of fluorescence correlation spectroscopy with fluorescence time-correlated lifetime measurements to determine the fluorescence emission of diffusing dye molecules, the researchers show that the plasmonic properties of the structure are affected dramatically by the adhesion layer's properties. Specifically, they found a striking 25-fold fluorescence enhancement for a 10 nm TiO_2 layer, more than 3× higher than the enhancement found for a 10 nm Ti layer. The authors note that these data strongly support careful consideration of the adhesion layer when designing nanoantennas for high-efficiency single-molecule analysis and indicate that 10 nm TiO_2 may be the optimal choice based upon their results.



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