Abstract: Research in nanophotonics, the science of light-matter interactions below the optical wavelength scale, is yielding advances that are opening paths for conceptually new “grand challenge” photonic technologies that have not previously been achievable. I will discuss three examples. The first is realization of comprehensively tunable nanoantenna arrays, which enable dynamic, active control of the constitutive properties of light, opening new applications such as phased-array optical beam steering, visible light modulation for communication and thermal radiation management. A second grand challenge is bringing next-generation solar energy technology to fruition. Nanophotonic design has enabled new directions for beyond-Si photovoltaics, such as luminescent solar concentrators that can enable an efficient and stable approach to tandem-on-Si photovoltaics. Nanostructure design is also critical to generation of chemical fuels from sunlight, and recent advances in nanostructures have allowed photoelectrochemical water splitting with record efficiency. A final grand challenge for nanophotonics is design of spacecraft capable of reaching the stars beyond our solar system, since light itself is the only fuel capable of propelling spacecraft to the relativistic speeds needed to achieve interstellar travel. The Breakthrough Starshot initiative has captured scientific imagination and motivated thinking about prototypes for light-driven spacecraft that could reach nearby stars.

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