duced in HIV-infected individuals, and why is NTS bacteremia only observed in patients with advanced HIV disease? The excess of antibodies to LPS in the serum of HIV-infected individuals was only weakly associated with hypergammaglobulinemia (increased antibodies in the blood), suggesting that polyclonal activation was not driving the expansion of LPS-specific antibodies. One explanation may relate to elevated amounts of LPS in the plasma of HIV-infected individuals. This is thought to result from HIV-induced disruption of the gastrointestinal mucosa and leakage or translocation of LPS from the gut into the circulation. (*8*). MacLennan *et al*. did not find a correlation between the concentrations of plasma LPS and LPS-specific antibodies, whereas there was a good correlation between the latter and impaired NTS killing (*3*). However, LPS might be associated with LPS-specific antibodies in complexes that are cleared from the circulation too rapidly for detection.

The presence of LPS-specific antibodies is likely to be only one of many defects responsible for NTS bacteremia in advanced HIV disease. NTS bacteremia in immunocompromised individuals, including HIV-infected individuals, has been associated with defects in cell-mediated immunity, including cytokine deficiencies (*4*). In this regard, interleukin-17 deficiency induced by simian immunodeficiency virus infection was associated with NTS bacteremia, and a similar scenario was proposed for HIV infection (*9*).

The results of MacLennan *et al*. may have practical implications for vaccine development. Their findings suggest that bacterial outer-membrane proteins of NTS, as opposed to LPS, should be the preferred vaccine target because LPS could potentially elicit inhibitory rather than the desired bactericidal antibodies.

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APPLIED PHYSICS

The Case for Plasmonics

Light-induced surface excitations may offer a route to faster, smaller, and more efficient electronics as well as new technology opportunities.

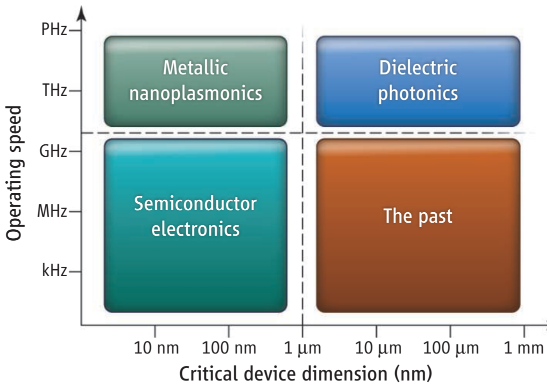
Mark L. Brongersma,[1] and Vladimir M. Shalaev[2]

Just over a decade ago, the term "plasmonics" was coined for a promising new device technology that aims to exploit the unique optical properties of metallic nanostructures to enable routing and active manipulation of light at the nanoscale (*1*). At the same time, it was already well established that tiny metallic particles have a number of valuable optical properties that are derived from their ability to support collective light-induced electronic excitations, known as surface plasmons. Most notably, nanostructured metals dramatically alter the way light scatters from molecules, and this later led to the development of an important optical spectroscopy technique called surface-enhanced Raman spectroscopy (*2*–*4*).

The plasmonics field exploded when it was demonstrated that metallic nanowires enable much smaller optical circuitry than dielectric (e.g., glass) waveguides (*5*), metal films with nanoscale holes can show extraordinarily high optical transmission (*6*), and a simple thin film of metal can serve as an optical lens (*7*). Plasmonic elements are also important as popular components of metamaterials—artificial optical materials with rationally designed geometries and arrangements of nanoscale building blocks. The burgeoning field of transformation optics elegantly describes how such materials can facilitate an unprecedented control over light by "engineering optical space" with local control of a metamaterial's response (*8*). As these novel phenomena captured the imagination of a broad audience, some of the severe limitations of metals were being recognized. The most important challenge is that metals exhibit substantial resistive heating losses when they interact with light. We have an opportunity to look back, evaluate the progress in the field, and look at promising future directions.

Plasmonics has enabled both exciting, new fundamental science and some real-life applications. The most important advances rely heavily on one key property of engineered metallic structures: that they exhibit an unparalleled ability to concentrate light. Even a simple spherical metallic nanoparticle can serve as a tiny antenna capable of capturing and concentrating light waves. By squeezing light into nanoscale volumes, plasmonic elements allow for fundamental studies of light-matter interactions at length scales that were otherwise inaccessible.

A diverse set of plasmonics applications has emerged in the past 10 years. Early applications included the development of high-performance near-field optical microscopy and biosensing methods. More recently, many new technologies have emerged in which the use of plasmonics seems promising, including thermally assisted magnetic



Of size and speed. The different domains in terms of operating speed and device sizes rely on the unique material properties of semiconductors (electronics), insulators (photonics), and metals (plasmonics). The dashed lines indicate physical limitations of different technologies; semiconductor electronics is limited in speed by heat generation and interconnect delay time issues to about 10 GHz. Dielectric photonics is limited in size by the fundamental laws of diffraction. Plasmonics can serve as a bridge between photonics and nanoelectronics.

[1]Geballe Laboratory for Advanced Materials and Materials Science and Engineering Department, Stanford University, Stanford, CA 94305, USA. [2]Birck Nanotechnology Center and School of Electrical and Computer Engineering, Purdue University, West Lafayette, IN 47907, USA. E-mail: brongersma@stanford.edu; shalaev@purdue.edu

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recording (*9*), thermal cancer treatment (*10*), catalysis and nanostructure growth (*11*), and computer chips (*12*, *13*). Interestingly, the first three applications in this list capitalize on light-induced heating, which was originally considered as a weakness of plasmonics. After the discovery that long-distance information transport on chips with plasmonic waveguides would suffer too strongly from heating effects (*14*), it now has been established that modulators (*12*) and detectors (*13*) can be realized that meet the stringent power, speed, and materials requirements necessary to incorporate plasmonics into conventional electronics technology. Plasmonic sources capable of efficiently coupling quantum emitters to a single, well-defined optical mode may first find applications in the field of quantum plasmonics and later in power-efficient chip-scale sources (*15*, *16*). In this respect, the recent prediction (*17*) and realization (*18–20*) of coherent nanometallic light sources constitutes an extremely important development. Looking even further down the line, the recent prediction that a surface plasmon laser may operate as an ultrafast amplifier is certainly stimulating. Could one build ultrafast logic circuits with devices that perform a similar function as the ubiquitous transistor but are orders of magnitude faster (*21*)?

As the complexity of plasmonic systems increases, the development of simple design rules for components is absolutely essential. The power of good design rules lies in their ability to hide much of the complexity within an individual device. Instead, the aim is to capture the essence of the device function and focus on its interactions with other devices. Such simplifications then enable the construction of system-level theories and simulators that can predict the behavior of larger circuits. Engheta recently developed an elegant theoretical framework that treats nanostructured optical or "metactronic" circuits much akin to conventional electronic circuitry (*22*)—insulators are modeled as capacitors, metals as inductors, and energy dissipation (heating) can be accounted for by introducing resistors. The desired response of an optical circuit can now be realized through the optimization of a little electronic circuit.

It has become clear what role plasmonics can play in future device technologies and how it can complement electronics and conventional photonics (see the figure). Each of these device technologies can perform unique functions that play to the strength of the key materials. The electrical properties of semiconductors enable the realization of truly nanoscale elements for computation and information storage. The high transparency of dielectrics facilitates information transport over long distances and at incredible data rates. Unfortunately, semiconductor electronics is limited in speed by interconnect delay-time issues, and dielectric photonics is limited in size by the fundamental laws of diffraction. Plasmonics offers the opportunity to combine the size of nanoelectronics and the speed of dielectric photonics, enabling devices that might naturally interface with similar-speed photonic devices and with similar-size electronic components, thus enhancing the synergy between these technologies. The semiconductor and photonics industries have continued to develop rapidly, and it will be exciting to see what the next decade will bring for plasmonics.

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PHYSICS

Sign Flips and Spin Fluctuations in Iron High-T_c Superconductors

The symmetry of electron-pairing interactions in iron-based superconductors suggests a shared spin-mediated pairing mechanism with the cuprate family.

Jennifer E. Hoffman

In superconductors, the key process that allows current to travel without resistance is the formation of electron pairs that move as a single quantum state. The mechanism of pairing in the high-temperature (high-T_c) cuprate superconductors is still elusive, so the recent discovery of iron-based superconductors (*1*) sparked the hope that comparison with the cuprates would lead to a better understanding of pairing in both materials. On page 474 of this issue, Hanaguri *et al*. (*2*) report the experimental determination of the pairing symmetry in $FeSe_xTe_{1-x}$. Combined with the recent observation of a spin fluctuation resonance in this material (*3*) akin to that seen in the cuprates (*4*), a compelling hypothesis emerges that these high-T_c superconductors share a common pairing mechanism.

Pairing in both conventional and high-T_c superconductors must overcome the large repulsive force between two like charges. In conventional superconductors, pairing arises from a normal metallic state, where electrons are numerous and move freely to screen any local inhomogeneity. One electron plus all of the screening electrons act like a single "quasiparticle." Despite the strong repulsion that should arise between any two isolated electrons, even a small attractive interaction such as a phonon—a wake of displaced ions—causes the pairing of quasiparticles. In conventional superconductors, phonon mediated pairing is typically isotropic, with spherical or "*s*-wave" symmetry.

In high-T_c cuprates, the story is more complicated because their "normal" state has too few charge carriers to screen effectively. Electrons interact quite strongly, allowing

Department of Physics, Harvard University, Cambridge, MA 02138, USA. E-mail: jhoffman@physics.harvard.edu