Commercializing plasmonics

Bringing plasmonics out of the lab is important. University support and communication between researchers and industry play a vital role.

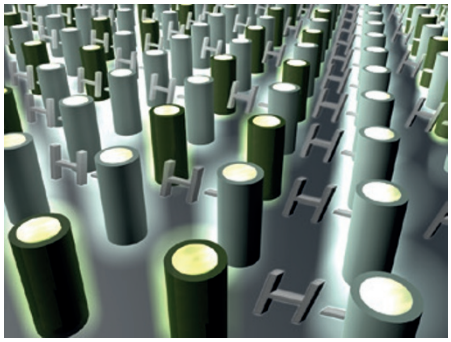
Since the first prediction of their existence in 1957 by Rufus Ritchie, surface plasmons have attracted tremendous attention because of their unique properties and potential applications in many fields ranging from biological sensing and biomedicine through to photovoltaics and data storage. Essentially, anywhere strong confinement of the electromagnetic field is an important ingredient, plasmonics will give an edge.

Realizing practical applications of plasmonics is a boiling issue in the community and moving plasmonics out of the lab to industry is the next step. The latter was precisely the main topic discussed during a roundtable discussion at the final Active Plasmonics project meeting and the London Plasmonics Forum held at King's College London, UK, on 18 June 2015. The general feeling was that it is not straightforward to commercialize plasmonics devices.

"Every technology goes through a so-called technology hype cycle. Unfortunately, or fortunately, due to many diverse applications of plasmonics, it is impossible to talk about such a hype cycle for plasmonics as a whole. This makes it look like progress is slow. We should look at a hype cycle for each of the application areas of plasmonics," remarked Anatoly Zayats from King's College London, who is the chair of the Active Plasmonics project. He elaborated that for sensing applications, plasmonics is well into a steady commercialization phase; for others, it is in different stages of testing and validation. "Ultimately, the more sophisticated an industry is, the more difficult to propose new solutions for it, as it should fit the fabrication process [of different applications]."

According to Stefan Maier from Imperial College London, who is the co-chair of the project, large-scale nanofabrication of plasmonic devices and the ability to scale up play a crucial role in the commercialization process. "Also, some common plasmonic materials like silver and gold are not entirely compatible with industry fabrication workflows," he pointed out. Indeed, apart from being lossy and expensive, silver and gold are not tunable and not suitable for on-chip integration.

As a matter of fact, there are only a handful of companies currently selling plasmonics products for sensing. Some examples are Renishaw Diagnostics, the supplier of Klarite, a surface-enhanced Raman scattering (SERS) substrate used for the measurement of trace materials in chemical and biological applications, Cabot Corporation, which in 2010 bought Oxonica Materials, a leading developer of SERS materials and detection methods, and Causeway Sensors, a spin-off company from Queen's University of Belfast that has developed novel nanostructured surfaces for sensing applications.



WAYNE DICKSON, KING'S COLLEGE LONDON

It has been a concern of the community that plasmonics may soon lose its popularity unless some real-world applications are found (see News and Views on page 487). Now, will the lack of a successful commercialization story dissuade the community from research into real-world applications, worsening the concern?

Maier stayed firm, saying "I don't think this is the case. Most of the areas where there is a lot of research now have initial products on the market, and interdisciplinary basic research in the field is constantly growing."

Holding a similar opinion, Zayats said "I think this question just emphasizes the problem of plasmonics as an enabling technology for many applications. Plasmonics already has many real-world applications in biological and chemical sensing. Photo-thermal cancer treatment based on plasmonic effects in nanoparticles is in clinical trials. Nobody disputes applications of plasmonics in heat-assisted magnetic recording. Several small companies are developing thermo-optical plasmonic modulators for silicon photonics. As soon as a research area moves to real potential applications, it loses popularity, as this stage requires a very hard work routine, and the results can't be published in high-ranked journals."

One of the obvious solutions to make plasmonics commercialization happen is to bridge the gap between the university and the industry, and that would require more communication between them to understand the problems and the potential advantages of plasmonics. Another obvious solution is to find new materials that are less lossy and CMOS-compatible. The responses from the attendees of the meeting converged.

To Zayats, the ultimate goal of any research is to make our life better, but not everything will be made into commercial products. The same is valid for plasmonics. It began as a fascinating phenomenon of light trapping by coupling it to electrons near a metal surface. Many possible applications were proposed. Some seemed to be superior to other technologies and were commercialized, some are still under intense testing and optimization, and some are without demand at present but may well be required in the future. It is a long journey from a lab demo of the effect to its optimization and development to industry standards in terms of fabrication tolerances, reliability and so on.

"University research may and should take a more long-term view and work on something that industry may need in the future, not necessarily tomorrow," urged Zayats.

The applications of biosensing have already, for a long time, been commercialized. When asked which applications will be commercializable plasmonics products in the near future, Zayats expected that heat-assisted magnetic recording, which is based on the ability of plasmonic structures to concentrate light on deep-subwavelength scales would be the next. All major magnetic recording companies, such as Seagate, one of the project partners, are working on it now, he added.

"In a few years, hard drives on the market will include plasmonic components for local heat generation to improve data storage capacity. I think heat-assisted magnetic recording will be the major success story of commercialization apart from biosensing," seconded Maier.

Zayats also envisaged that plasmonics-enhanced nonlinear optical components for signal conditioning in fibre and integrated photonics, in which Intel, another project partner, has shown interest, and nanolasers for bioimaging will have great potential for commercialization soon. ❐