FLAGSHIP

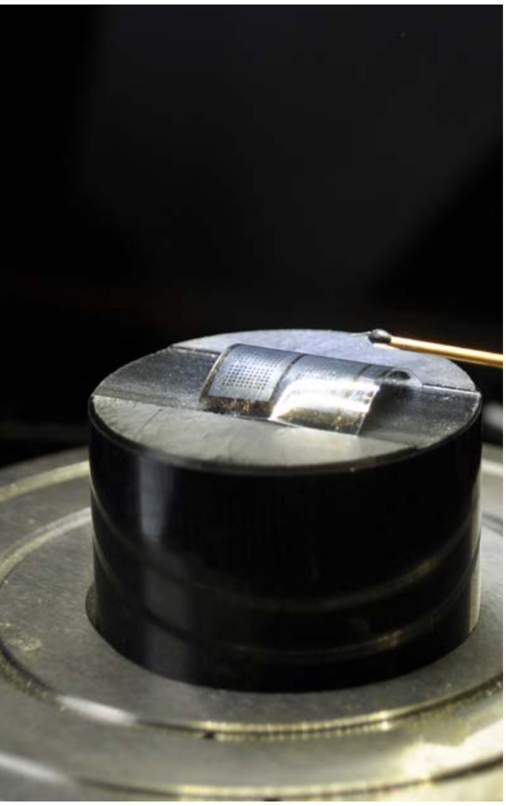
ADVANCED MANUFACTURING PROCESSES

Plastic nanoelectronics by adhesion lithography (PLANALITH)

INVESTIGATORS
THOMAS ANTHOPOULOS

INSTITUTION
IMPERIAL COLLEGE LONDON

RFID has existed for decades. While the technology has made many of our lives easier with the likes of contactless payment, electronic toll collection and convenient key fobs, the largest benefits have come in B2B applications, with the radical improvement in efficiency in the supply chains of many businesses. Particularly, ultra-high frequency (UHF) RFID tags have allowed for drastic improvements in asset management. With advances in large-area electronics, we are now on the cusp of rolling out this technology for a whole host of new applications, including complete barcode replacement. Work on the PLANALITH project has striven to deliver a missing component, a low cost printed rectifier, to allow this for the first time.

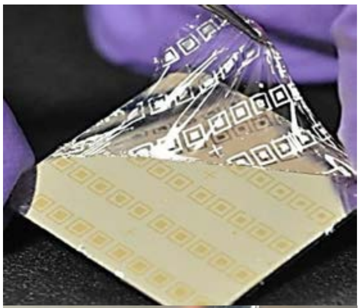


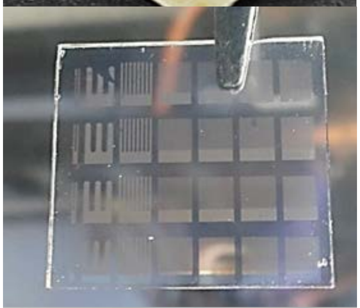
When it comes to RFID manufacture, there is and always has been a question of tag price vs. performance. High quality electronics are needed, but at a low cost. For the type of ubiquitous tagging that the industry leaders envisage, a cost of less than £ 0.01 for next generation tags is needed. Carrying out a cost analysis, one finds that printing the entire tag (including the electronic components) cuts out the two largest costs (chip manufacture and integration) and enables tags in this price bracket.

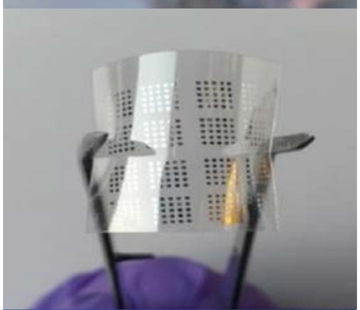
An RFID tag has three components: antenna, rectifier and logic circuitry. Currently industry can print two components, the antenna and the logic circuitry. However, without all three components, the cost reduction is irrelevant. Over the last 2 years, the technology to print a rectifier at low cost, capable of operating in the industry required conditions has been developed.

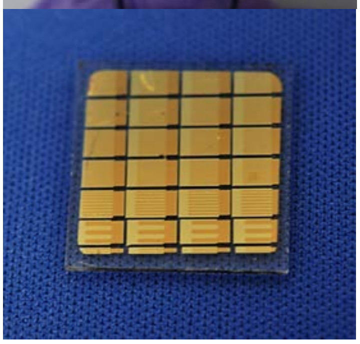
This seemingly simple component has been elusive to researchers globally in the past, due to apparent limitations in printed semiconductor material performance. Intrinsically lower electron mobilities as compared to high-end silicon seemed to be a bottleneck for high frequency printed electronics. This roadblock could only be overcome through a paradigm shift in terms of device physics.

As such, the PLANALITH project has sought to redefine the manufacturing methodology for simple electronic components (such as diodes). By focusing on device architecture rather than material performance, and leveraging unique and mass scalable nanofabrication techniques developed at Imperial College over the last 5 years, several breakthrough results have been achieved. These are interesting from a fundamental engineering perspective (such as the “world’s largest nanofeature”, a continuous nanofeature with a width to length ratio of > 100,000,000) as well as from an immediate industrial standpoint (the world’s fastest printed diode, a repeatable printed Schottky diode operating at GSM frequencies for the first time).









True to the nature of innovation and disruptive progress, these results have come from the convergence of many different ways of thinking and from a team with a diverse background. The approach involved the reimagining of a fundamental circuit component design, the rapid development of a nanogap electrode fabrication technique just invented (namely adhesion lithography), the incorporation of novel solution processed semiconductors using new low temperature methods (such as ZnO) and the high-end precision electronic testing. As such, assembling the team of physicists, materials, chemical and electronic engineers was one of the real challenges to be overcome, but once done, progress was swift.

Industry interaction

Globally, the RFID market is valued at over $12 billion. Tags which operate in different frequency ranges have different applications, and thus the market is segmented by frequency. Traditionally, high frequency (HF) has been the market leader in RFID. However, market research suggests that as of 2017, UHF RFID tags have surpassed HF tags in sales volume. This is due to massive growth over the last decade owing partly to adoption by major players in the retail space. Over the next decade, UHF tags are expected to secure dominance in the RFID sector, experiencing the highest growth, with > 10 % CAGR expected until 2026.

Previously slowed down by technological roadblocks, progress is now restricted by tag manufacturing cost alone. Given the maturity of the technology, it is highly likely that tag manufacture will be done solely via printing techniques, as opposed to the integration of silicon chips with printed antennas carried out today.

We have developed a component that allows AC/DC conversion of both HF and UHF signals for use in RFID tags, a completely unique capability. The issue that now needs to be addressed is how to move this a-Lith technique towards being a reproducible manufacturing process for the production of high frequency diodes. It is this aspect that the new PLANALITH4Manufacture project will address. We have had strong interest from a range of industries and look forward to further engagement in the near future.

Contact:
Professor Andrew Flewitt: ajf23@eng.cam.ac.uk

All photo credit: James Semple and Dimitra Georgiadou