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Innovation Frontier

RFID Technology: the ultimate "Internet of Things"

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The most ubiquitous chip.

Chips are everywhere, and some semiconductor companies such as NVidia have become almost household names, prominent in news headlines and investor conversations. Yet one of the most ubiquitous semiconductor products around, RFID chips, remains relatively obscure. We don't think this will last long. Over 100 billion of these chips have been shipped since 2010, growing at nearly 30% per year according to the RAIN RFID industry alliance. These devices can be found in many everyday products, from car tyres to clothes, and are likely to become significantly more widespread in the coming years.

In this paper we look at the history of this technology, the impact it is already making on global industries and some exciting new applications and opportunities ahead.

History of war and espionage.

Like many technological breakthroughs before it, RFID technology started life in warfare and geopolitical conflict.

It was simultaneously developed by British engineers and Soviet spies. In wartime Britain, it was a byproduct of radar technology, when operators noticed that the radar signature of returning British planes could be altered to help discern friendly from incoming enemy aircraft. This was engineered into RAF "Identification friend or foe" (IFF) technology, becoming a first "passive" radio identification system working on the reflection of incoming radio waves.

Meanwhile, in Moscow a listening device disguised as a wood carving was planted by the Soviet intelligence in the US Embassy. It contained a microphone and a passive radio circuit which, when "illuminated" by the radio waves from outside the building, broadcast the conversation in the room. Like the British IFF technology, this bug used external radio waves to "energise" the device to transmit the information back to the listener. This principle remains at the heart of the modern RFID technology, even though its uses today are a lot more benign.



Antennae for IFF Mark II on the side of the British Spitfire aircraft (*Source: Wikipedia*)

Radio frequency identification (**RFID**) is a form of wireless communication that uses radio waves to identify and track objects.



Principles of RFID technology (Source: Impinj)

The tipping point in RFID adoption

Chip costs have plummeted as the technology has advanced, making RFID a viable solution for many high volume applications. RFID chips themselves can be as cheap as 1 cent, or up to 3 cents if encapsulated in a label or tag. This is cheaper than the barcode, according to industry experts, once the labour cost of scanning is factored in.

RFID technology is far superior to many previous labelling or tracking alternatives: labels can be read from up to 30 feet away, with no line of sight, in the dark, at speeds of up to 1,000 labels per second. No wonder the technology is rapidly proliferating across industries. Many of our readers will have encountered the most consumer-facing RFID use case – automated retail store self-check-out. From sports retailer Decathlon to fast fashion retailer Uniqlo (below), consumers simply put their shopping in a RFID-enabled bin and all their purchases are added up to a final bill. No more manual scanning of bar codes or waiting in the queue for the check-out assistant.



Uniqlo RID self-checkout station (Source: Impinj)

Another retail use is "loss prevention", a polite industry term for combatting shoplifting. Once the goods are paid for, RFID tag is wirelessly switched into "paid" status, and shopper can walk out. If not, the tag triggers the alarm at the reader gate. This avoids the complexity and cost of attaching and removing magnetic tags and means stolen goods cannot be returned.

Behind the scenes, RFID also helps inventory tracking. Inventory accuracy is a big pain point for the industry. A recent study found that RFID increased inventory accuracy from 63% to 95% - a dramatic improvement, helping locate the inventory and avoid running out of stock. RFID projects in retail boast very high returns on investment and short payback periods.



Inventory Control with RFID scanner (Source: Zebra Technologies)

Leading global retailers, from Uniqlo to Zara to Wal-Mart are adopting RFID across their merchandise categories. Wal-Mart is effectively mandating all of its suppliers to become RFID enabled – likely leading to the domino effect of adoption across the industry.

Logistics is another application. UPS is rolling out RFID across its global parcel operations. Tags are already embedded in its shipping labels, while readers are installed in its warehouses, loading bays and soon its delivery trucks. This reduces the "mis-shipment" rate, shipping parcels to the wrong address, from as frequent as 1-in-400 to 1-in-1,000 or better. UPS has estimated that RFID technology will help it save up to \$500 million in annual costs.



Specialist and emerging use cases.

Some RFID applications are niche but transformative for the industries they serve.

The tyre industry is embedding RFID inside tyres. This helps with inventory tracking and authenticity control, and it can help manage tyre re-treading. Commercial vehicle tyres can only be safely refurbished a few times. RFID tag information helps retread the tyres with the right materials and in compliance with the safety rules. In auto assembly, RFID is used in connectors throughout the vehicle. RFID tags are activated when the correct assembly connection has been made. Readers at the end of the assembly line can instantly check the connection integrity of multiple points in the car, streamlining quality control.

Exciting new large volume applications are beginning to open up as well.

Healthcare is one – the industry is conservative and heavily regulated but is beginning to recognise the huge value that RFID technology can bring through inventory control and tracking, medicine authenticity control and even point-of-use checks before the medicine is injected or infused into a patient. Specialist pharmaceutical packaging companies, such as Schott Pharma (below) and Gerresheimer, are incorporating RFID tags into their vials and syringes.



Schott Pharma RFID enabled pharmaceuticals packaging *Source: Schott Pharma.*

Even food, potentially the largest market by units, is now within reach. Supermarket chains are looking to tag the packaging for bakery products, to ensure that the store keeps tabs on the freshness and expiry dates. Here, the prize is avoiding food waste, estimated to cost as much as 1 billion dollars per year to some of the largest retailers.

Ambient Internet of Things and RFID in every smartphone.

The industry has an even bolder vision. RFID Technologists talk about an "ambient internet of things", a collection of tags and beacons wirelessly communicating with each other, their users and the cloud to create a permanent picture of the world around us, where location and status of everything is known, monitored and which drives insights, productivity, sustainability and efficiency across industries. Part of that vision involves putting RFID technology into phones: 5G antennae can already operate on RFID frequency and incremental software and the hardware content needed to enable this is minimal. Imagine the world where a device in our pocket can locate any object in our lives that's tagged with RFID tags (subject to obvious privacy and safety guardrails). This tantalising prospect is still some way away, but the industry is actively pursuing it.

Consumable semiconductors and after-market revenue streams.

Not only is RFID the most ubiquitous of chips, but they also bring the most recurring revenues. Usually, the best semiconductor investors could hope for is to have their chips in smartphones - those refresh every 2-3 years. PCs and servers have longer refresh cycles, and industrial and auto applications replacement times can take over 5 years. With RFID, every Zara jumper or UPS parcel uses a chip. This is a better quality of revenues and earnings - consumables, not durable goods. It can get even better: the industry is working on aftermarket revenue models. One such opportunity is authentication. RFID chips can carry a cryptographic key that can be cross-checked with the product record in the cloud, to confirm that a vial of medicine or a luxury handbag are authentic. This brings a transaction fee which would be multiplied by millions of units in the field. This is even better than the traditional chips business model.

Consolidated industry with deep moats.

We often find that when niche technologies hit prime time, their underlying industries have a reassuringly consolidated structure. Small markets cannot sustain many players, and many years of R&D tend to result in proprietary IP or know-how. When the tipping point occurs, accelerating growth accrues to these longsuffering specialist suppliers whose time has finally come. RFID looks to be such a case. Only two companies in the western world are credible suppliers of RFID chips – US listed Impinj and a division of NXP Semiconductors. The two companies had an IP dispute, which has been resolved in Impinj's favour, showing the strength of its IP.

Despite their diminutive size, RFID chips are a complex technology – they need to be cheap, tightly packed on a wafer and function reliably in a variety of real world conditions, where moisture, obstructions and mechanical and thermal stresses abound.

Further down the value chain, the challenges and the moats are different: RFID chips are encapsulated ("inlaid") into labels and tags, sometimes even integrated into garment threads, and need to be distributed to the point of use so that retailers or logistics operators always have the right inventory at hand. . Hardware that encodes and reads the labels (often in conjunction with printing or reading barcodes, QR codes and shipping addresses) presents another challenge.

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As a result, the business of making and distributing these "intelligent labels" is consolidated towards few leaders, such as Avery Dennison, while companies like Zebra Technologies and Honeywell dominate the reader and printer equipment business.

In our experience, this is a promising combination. Here is a growing industry, which by some measures has less than 1% penetration in its target markets, with multiple years of growth ahead. It is consolidated and comprised of profitable companies with defensible competitive moats.

RFID technology has already contributed positively to the WS Amati Global Innovation fund returns and we retain a significant exposure to the space in anticipation of further growth.

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