

# Radio Frequency ID Tags

What They Are, How They Can Be Used and How  
Production Costs Can Be Reduced.

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## **Abstract**

Radio Frequency ID (RFID) is a new technology that hopes to replace barcodes. However, at this point, RFID “tags” can cost around €0.45 each, much too expensive to replace the barcode on a trivial item such as a carton of milk or a bar of chocolate.

There are various companies and organisations who hope to bring the price of RFID tags to below €0.045, which they feel will be affordable by most product manufacturers.

In this paper, we look at the history of RFID, in what areas it can be put to use, and how, through redesigning the manufacturing process, the cost of these RFID tags can be drastically reduced, thus making them a viable alternative to barcodes.

## **Introduction**

Barcodes, which have been in widespread use for the last 25 years, are the primary way to tag goods and products in today's economy. However, they have several disadvantages, such as requiring line-of-sight to read them and containing very little information on the barcode itself. Radio Frequency IDs (RFIDs) hope to provide these missing functions and, in time, replace barcodes altogether. RFIDs consist of a reader and a "tag" which has a small integrated circuit and an antenna onboard. One of the main obstacles to RFIDs' takeover is the current cost of producing them. In this article, we will look at what RFIDs are, how they can be used and in what ways the current prohibitive cost of production can be reduced.

Some of the main differences between barcodes and RFIDs are the information that can be stored on them, and the ways in which they can be read. When a barcode is scanned, say at a supermarket checkout, the code is read and looked up in a stored database. In this way, the scanner can find the name and price of a product. An RFID performs a similar operation, but a lot more information can be stored on the RFID tag, such as an expiry date on a carton of milk, or even an individual ID for more expensive products. An RFID tag, however, does not need to be scanned, it can be read from any angle, through obstacles such as paint or dirt and even buried under other items.

This added functionality has many applications in nearly every area of modern life. One example would be taking stock in a large warehouse. If each item was fitted with a tag, an inventory could be automatically updated if an item was removed or added to the shelves. RFID could also be of great use in a supermarket, where a customer could fill their shopping trolley with goods and have it automatically scanned as they walked out the door. In the home, a washing machine could read the tags on clothes and know automatically what temperature to wash them at.

However, at the moment RFID tags cost in the region of €0.45<sup>i</sup>, which is quite an overhead to put on cheaper items. The Auto-ID centre at Massachusetts Institute of Technology is trying to find ways to manufacture the tags at about a tenth of the current price, which they feel will make RFID an affordable technology. But even if the cost of manufacturing and assembly was reduced and the demand for RFIDs grew overnight, current manufacturers would find it difficult to mass-produce the tags. If these two problems were overcome, RFIDs would be well on the way to replacing barcodes.

## **Uses of RFID.**

As has been mentioned, RFIDs have applications in nearly every area of modern life. But why would someone adopt this new and relatively expensive technology over the tried and tested technology of the barcode? The advantages are manifold, but the main advantage is automation of tasks. A manufacturer could track an entire order as it leaves its factory and arrives at the customer. On receipt of the product, the customer could be automatically invoiced. In the future, a supermarket shelf could “count” the quantity of a product on it, and alert a manager that more should be ordered<sup>ii</sup>.

Another advantage would be interactivity with products. For example, a product could automatically reduce itself in price as it nears its sell-by-date. The Auto-ID Centre at MIT wants to create an “internet of things” so that every item on the planet could be connected to each other. This would allow you, for example, to ask a computer where you left the television remote or where you lost your wallet.

RFID isn't just theory, it has already been put into practice. In New York, American Express have introduced a “key-ring tag” that allows a user to fill their tray in a cafeteria and, simply by touching their tag to a reader, they can be automatically charged for their purchase<sup>iii</sup>. This has reduced the queuing time by 30-40%. In England, Boots Pharmacy has introduced tags on a range of products that allow security cameras to take a picture of anyone trying to shoplift from their store.

## **The Future Of RFID.**

There are a number of companies and organisations that are trying to promote the use of RFID, situated mainly in the US but also in Europe.

Currently, a typical tag can only be read from a metre or so away, but the Pacific Northwest National Laboratory (PNNL)<sup>iv</sup>, a US government funded research centre, have made it their aim to design tags that can transmit up to a hundred metres. Another organisation, which has already been mentioned, is the Auto-ID Centre at MIT<sup>v</sup>. The Auto-ID Centre's mission is to promote standards related to RFID tags and to bring the cost of tags below €0.045.

Companies who are leading the way in promoting RFID include Texas Instruments<sup>vi</sup> in the US, Omron<sup>vii</sup> in Austria and Nedap<sup>viii</sup> in the UK. But

it is Alien Technologies, an American company, who are really pushing the envelope with their production techniques.

But, as mentioned earlier, RFID has no future unless it can overcome the obstacles of cost and mass production.

### **The Anatomy of an RFID Tag.**

An RFID system consists of three things, a reader or interrogator to read the information and, on the tag, a computer chip (IC) with an antenna. See figure 1 to see how these are organised.

The main difference between tags is whether they are passive or active and whether they are read/write or simply read. An active tag has a small battery attached, which allows the tag to transmit to the reader. To reduce complexity and therefore costs, the battery can be removed to form a passive tag. These tags are powered by the radio waves from the reader as it tries to read it. The difference between read/write tags and read tags is the ability for information to be rewritten to the tag. Again, a read-only tag is another way to reduce costs.

Current passive tags can be read from about a metre away, but the PNNL, as has been mentioned, are working to increase this range up to a hundred metres. Passive tags vary in size from the size of a barcode to the size of a grain of sand<sup>ix</sup>.

### **Problems Preventing The Adoption of RFID.**

The two major problems preventing the adoption of RFID technology are the prohibitive cost and, if this was overcome, the inability to meet demand for replacing barcodes. Currently, the demand for RFID tags is about 500 million a year, nearly entirely from American companies. However, 5 billion barcodes are scanned per day worldwide, so there is a huge market there to be tapped<sup>x</sup>.

There are a number of ways in which costs could be reduced, both by modifying existing technology and by employing new production techniques. These include reducing the complexity of the tag, improving the production and assembly techniques and by changing the way the tags antenna is made.

One of the first things to do in reducing the complexity of RFID tags is to remove the battery, transforming them into passive tags. It makes

economical sense to have one reader power thousands of tags, if you can live with the reduced read-range. The Auto-ID Centre has proposed a set of standards, called the EPC (Electronic Product Code), which will be a 64bit or 96bit number stored on the tag. When this tag is read, the reader will look up it's EPC on an ONS (Object Name Server), which will tell the reader where to find information, related to the product. This is similar to the way a computer looks up an IP address on a Domain Name Server (DNS) to find the website you requested<sup>xi</sup>.

This standardisation has two purposes. It reduces the amount of information stored on the chip, further reducing complexity and price, and it allows manufacturers to make standard tags, which will work anywhere in the world, facilitating mass-production.

Another critical area in respect to redesign is the process the RFID tags go through in manufacture. Currently tags are manufactured in a similar way to computer chips. A sheet of silicon has small circuits printed on it in a variety of ways. These circuits are tested by applying voltages to them and monitoring the results. After this the silicon sheet is sliced into distinct "dies" or chips and is packaged. If RFID tags are to come down in price, this process is going to have to be dramatically redesigned.

One of the first ways to improve the efficiency of the process is to eliminate testing. The current practise of having a contact applied to each chip to test voltages would be a huge bottleneck in high-volume production. If the tags were tested wirelessly after they were produced, the manufacturing process could move along much more swiftly. Wireless reading would ideally be done at the client's site, just before the tags were applied to the product, and would be a simple matter of trying to read a chip and discarding unreadable tags.

On a single silicon wafer, many similar circuits are laid out. Etching is used to separate these circuits, but with current etching techniques large gaps are left between each circuit so the cutting doesn't damage the chips. These gaps are called "streets" and can be seen in figure 2. Circuits for RFID tags are small, but the gap between them has to be quite large to allow safe cutting. This can mean up to 75% of a silicon wafer is wasted in the etching process<sup>xii</sup>.

There are a number of new etching techniques, which will help reduce the cost of RFID tags. These include RIE, which uses reactive ions to separate the circuits, and Wet Etching, in which a thin line of acid is laid down to split the wafer. Theses techniques will greatly reduce the size of

the “streets” and therefore the amount of silicon wasted, a saving that can be passed on to the customer.

Another area that needs to be rethought is the assembly of the tags. With current technology, the IC and antenna are placed and wired using robotic assembly, a process known as “Pick and Place”. In high-volume production of RFID tags, this would be another huge bottleneck on the assembly line. Alternatives to the “Pick and Place” method are doing the wiring on the silicon wafer before the etching process or using vibrator assembly, which is being developed by Phillips. In a vibrator assembly process, chips are moved around by directing sound waves at them. By varying the frequency of the sound and the tilt of the wafer, entire tags can be assembled rapidly and with little physical contact.

One of the most promising methods of assembly, however, is Fluidic Self Assembly (FSA), soon to be put into practice by Alien Technologies. The circuits that Alien uses are etched using a Wet Etching technique. This has the effect of making each chip a uniform trapezoidal shape. These chips are about three times the width of a human hair and thousands of them are floated in a bath of alcohol. A roll of plastic is fed through the bath and the chips fall into, and fit snugly into, trapezoidal holes in the plastic. From here the antennas are attached to the chips, the newly made tags are sealed and separated, all in the rapid and automatic process of FSA<sup>xiii</sup>.

A final area that could reduce the cost of RFID tags is the material used to manufacture the antenna on the tag. One modern method, which is moving away from the old technology of twisted copper wiring, is the use of conductive ink, a process developed by Rafsec. This ink is then printed onto the tag before it is sealed, further reducing the cost and complexity of RFID technology.

## **Conclusion.**

It is easy to see the benefit of using RFID tags over conventional barcodes, but it is hard to justify their use at current prices. Tags will need to come down in price from the current €0.45 to around one tenth of that price. And it is believed by some that tags will not completely take over from barcodes until they drop below €0.01 in price<sup>xiv</sup>.

Even if the price could be reduced by this much, current IC manufacturing techniques would be unsuitable for the mass production of RFID tags. The biggest obstacles to the future of RFID technology is

seeing if people will adopt the recent advances in the manufacturing processes and the standards put forward by the Auto-ID centre. Until we see these barriers overcome, we will not have a global “internet of things”.

### **Further Reading.**

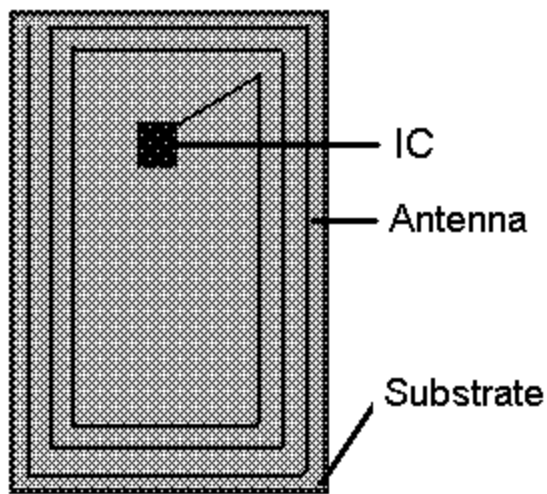
The Auto-ID Centre have published an “Idiots Guide” to RFID Technology. This gives a very good overview of their work and their vision of the future. It is available on their website at [http://www.autoidcenter.org/aboutthetech\\_idiotsguide.asp](http://www.autoidcenter.org/aboutthetech_idiotsguide.asp)

Sanjay Sarma or the Auto-ID Centre has published a very readable white paper entitled “Towards the 5c Tag”, which documents the need for RFID Tag manufacturers to embrace new production techniques. It is available at <http://www.autoidcenter.org/publishedresearch/MIT-AUTOID-WH-006.pdf>

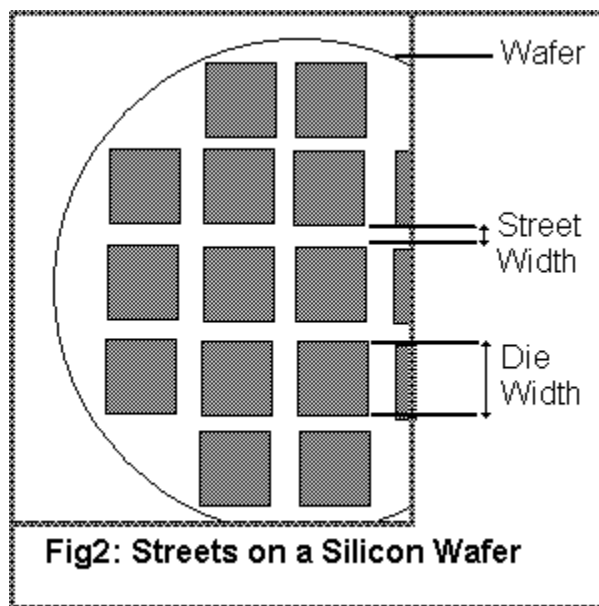
An article by Kevin Maney, published in USA Today on the 02/06/2002, documents his visit to Alien Technologies. It gives an overview of the FSA process and other applications of this technology, including RFID. It is available at <http://www.usatoday.com/tech/columnist/2001-03-14-maney.htm>

Texas Instruments have a press release documenting the adoption of RFID Technology by American Express. It shows a working real world example of RFID technology. It is available at <http://www.ti.com/tiris/docs/news/partner/2003/07-16-03.shtml>

**Illustrations.**



**Fig1. An RFID Tag**



**Fig2: Streets on a Silicon Wafer**

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- <sup>i</sup> See “Towards The 5c Tag” by Sanjay Sarma, Auto-ID Centre.  
<http://www.autoidcenter.org/publishedresearch/MIT-AUTOID-WH-006.pdf>
- <sup>ii</sup> See “Auto-ID Centres Idiots Guide” for their vision of the future with RFID.  
[http://www.autoidcenter.org/aboutthetech\\_idiotsguide.asp](http://www.autoidcenter.org/aboutthetech_idiotsguide.asp)
- <sup>iii</sup> See <http://www.ti.com/tiris/docs/news/partner/2003/07-16-03.shtml>
- <sup>iv</sup> See <http://www.pnl.gov>
- <sup>v</sup> See <http://www.autoidcentre.org>
- <sup>vi</sup> See <http://www.ti.com/tiris/>
- <sup>vii</sup> See <http://www.omron.com/card/rfid/>
- <sup>viii</sup> See <http://www.nedaprs.com>
- <sup>ix</sup> See <http://availabletechnologies.pnl.gov/securityelectronics/rftagsbg.stm>
- <sup>x</sup> Figures taken from Sarma, “Towards The 5c Tag”.
- <sup>xi</sup> See [http://www.autoidcenter.org/aboutthetech\\_indepthlook.asp](http://www.autoidcenter.org/aboutthetech_indepthlook.asp)
- <sup>xii</sup> Figure taken from Sarma, “Towards The 5c Tag”.
- <sup>xiii</sup> See [http://www.alientechnology.com/library/pdf/fsa\\_white\\_paper.pdf](http://www.alientechnology.com/library/pdf/fsa_white_paper.pdf)
- <sup>xiv</sup> Figure taken from Sarma, “Towards The 5c Tag”.