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Chip versus chipless for RFID applications

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www.idtechex.com

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IDTechEx is an independent strategic analyst on RFID, smart labels, smart packaging and printed electronics. Our core services provide:

Consultancy	Publications	Conferences
Clients include: Shell Oil Rexam Whirlpool Europe Guinness UDV Thin Film Electronics PolyTechnos Schiphol Airport…	• Independent market and technology research reports covering RFID, printed electronics & smart packaging topics • Two monthly journals, Printed Electronics Review and the world's largest RFID case study knowledgebase	Global Conferences: USA, Europe and Asia Smart Labels Smart Packaging Printed Electronics Food & Livestock Traceability Active RFID

RFID Yearly Market Potential

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Today, no more than several hundred million RFID devices are sold yearly. The potential is much larger:

Tens of millions	**Secure access, test tubes / blood samples, toys, vehicle immobilisers**
Hundreds of millions	**Laundry, library, livestock, logistics, assets security**
Billions to 100s of billions	**Pallets, cases, air baggage tags, smart paper tickets, banknotes, financial cards proof of ownership, archiving, parcels**
Trillions	**Supermarket barcodes, brand protection**

To get there, we need much lower cost tags and infrastructure / software

RFID in Packaging

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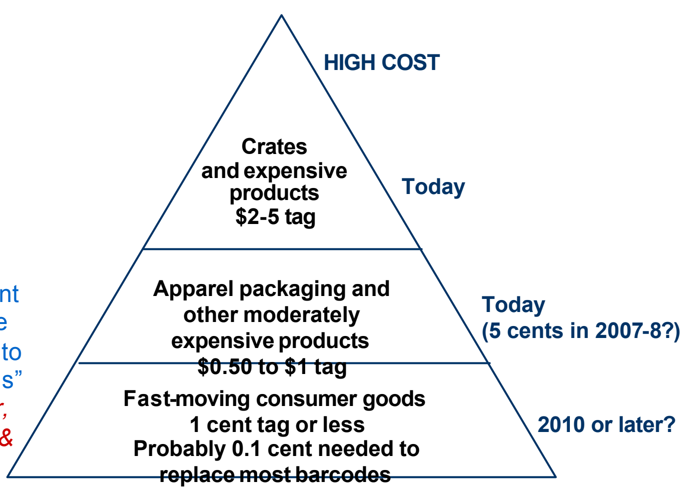
“One cent tag price needed to tag items”
Unilever, Procter & Gamble



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Technology overview

Increasing cost & sophistication

EAS (Electronic Article Surveillance 1 to 4 cents)
AC, LC or EM.

Chipless RFID (0.1 to 50 cents)

Distinct technologies: Microwave reflector, electronic circuits, thin film circuits.

Passive chip RFID (10 to 800 cents)

Ticket, label, card. Chip powered by the reader.

Active chip RFID (with battery from $1 to $100)

Long range (m), real time location, sensors.
Emits continuous signal for positioning.

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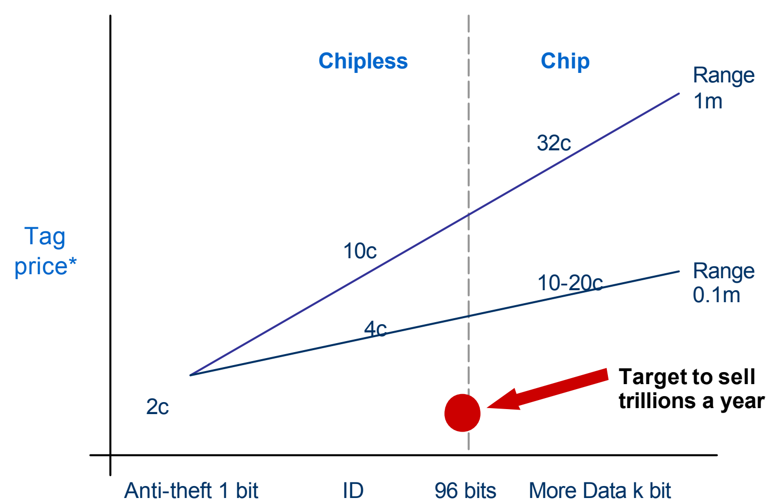
Tag Price Comparisons



*When bought in millions

Chip Smart Labels

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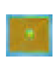
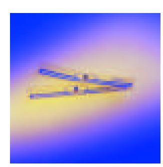
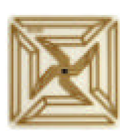
Passive RFID:
Main operating frequencies







125KHz=LF 13.56MHz=HF

Inductive antenna - flooding

UHF 2.45GHz

Electric antenna - beaming

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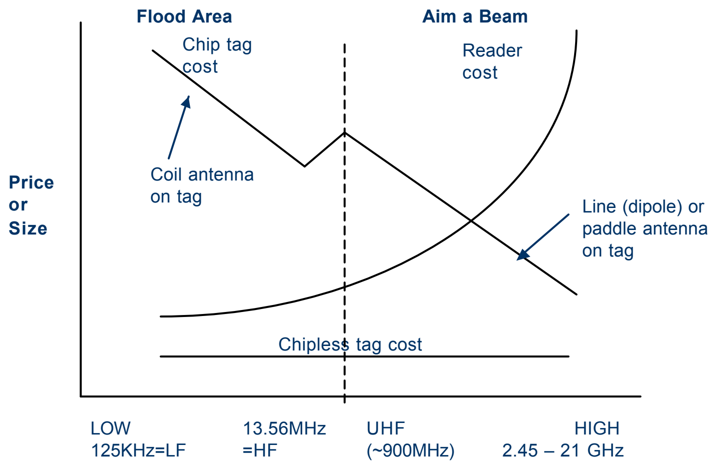
Frequency



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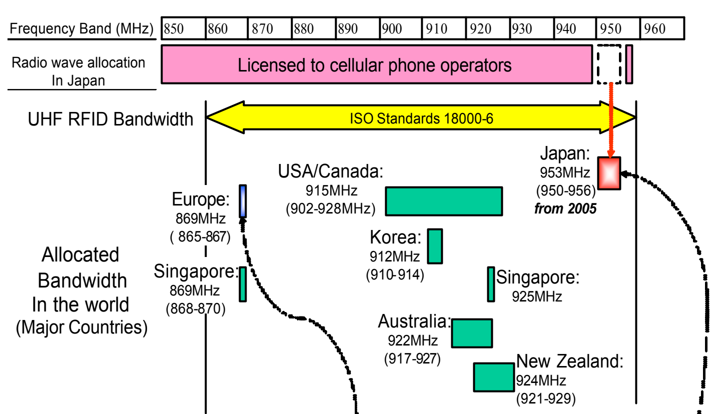
World UHF Band Allocation for RFID



For global compatibility of ISO 18000-6, Japan and Europe have extreme positions is both edges.

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Achieving the 5 cent tag

RFID tag component	Tag Cost: MIT Auto ID Center/EPC global (cents)	Tag Cost: Rafsec (cents)	Auto ID Center, and Rafsec's 5 cent tag aim (cents)
Chip	20	24	1
Antenna	5	7*	1
Chip placement	5	5	1
Chip connection	5		
Conversion to package	Over 10*	5	1
Total	Over 45	41	< 5

* Includes substrate cost

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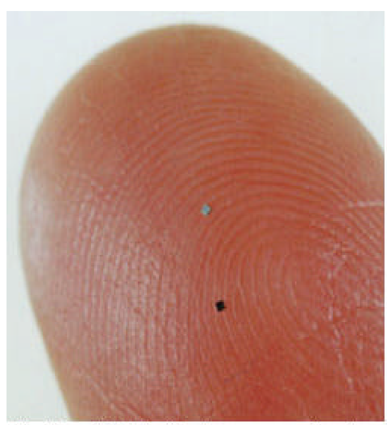
Ultra-small Chips are Very Important

e.g. eventually 0.1mm across, 20µm thick

- No supply famines?
- No brittleness problems
- Can go in paper etc
- Thin chips double as pressure sensors
- **Very low cost**



The Meu-chip is built using a conventional CMOS process.

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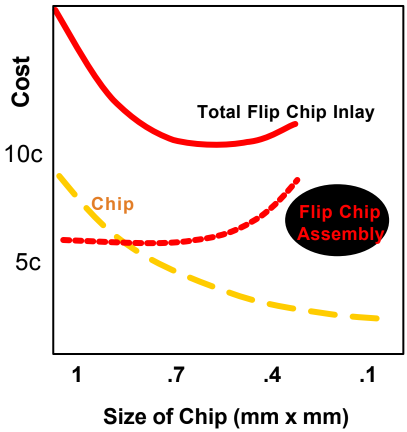
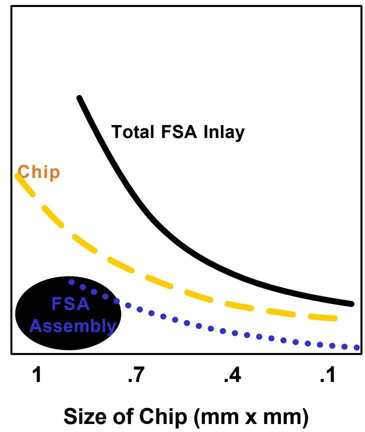
Scaling up Chip Bonding

The problem:
Flip Chip Cost Increases with Smaller ICs



The solution:
Fluidic Self Assembly / Vibration assembly Cost Decreases with Smaller ICs



Source: Alien Technology

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Chipless Smart Labels

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Digital Chipless Tags – Potential benefits

Remote magnetics	Magnetostrictive	35 million sold
	Simple Electromagnetic	Radiation hard. Thinnest option
	Barkhausen effect	70 million sold. Very secure
Transistorless circuits	Surface Acoustic Wave (SAW)	Millions sold, Meets standards. Radiation hard
	Diode based	Suitable for insect tracking
	Coil-capacitor (LC)	Hundreds of thousands sold. Thin and robust
Transistor circuits	Polymer Electronics	Printable onto products. Meets standards.
	Silicon film	High frequencies possible
	VTT/Panipol/Mreal pyridene tag – secret technology	Printable onto products. 96 bits EPC

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Digital Chipless Tags – Limitations

Remote magnetics	Magnetostrictive	Thick. Under 30 bits. Read only
	Simple Electromagnetic	Under 30 bits. Read only
	Barkhausen effect	Expensive. Read only. Few bits
Transistorless circuits	Surface Acoustic Wave (SAW)	Thick. Read only.
	Diode based	Analog. Read only
	Coil-capacitor (LC)	Large footprint. Under 30 bits.
Transistor circuits	Polymer Electronics	Not in production or radiation hard. No UHF or above
	Silicon film	Production process more expensive than polymer
	VTT/Panipol/Mreal pyridene tag – secret technology	Range only a few mm

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Two generations of chipless RFID

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FIRST GENERATION: Closed systems i.e. single service provider, no standards, usually little memory - anticounterfeiting, antitamper, secure access, product diversion, in house- track and trace, automated error prevention.
Acoustomagnetic, electromagnetic, LC Array

SECOND GENERATION: Open systems i.e. multiple service provider, global standards e.g. EPC. Barcode replacement and more -
SAW and later polymer TFTCs and maybe thin film silicon TFTCs and maybe the secret VTT/Panipol printed pyridene label which has 96 bits read only but only at a few mm range.

Electromagnetic Chipless Technology

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Confirm Technologies Israel

Link-Sure UK

Flying Null UK

MIT US

Example: Flying Null thread in a blister pack

- Range few centimetres (up to ~0.4m)
- World's thinnest and lowest cost tag

Flying Null can be used for machine readable

- Authentication
- Tamper Evidence
- Track and Trace

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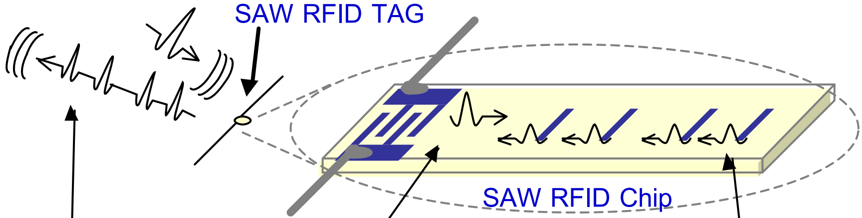
Surface Acoustic Wave (SAW) RFID Technology



Signal from Antenna to Interdigital Transducer
- Produces Pulse of Surface Acoustic Waves
- Uses Piezoelectric Crystal (not Silicon) Chip

SAW Reflections from RFID Pattern
- Produce Pulse Position Encoded Data

Pulse Train Leaving IDT
- Returns Encoded Signal to Reader

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Reading on Metal

SAW Tag with dipole antenna on coke can

Reading tags on metal, metal foil or containers of liquids is not a great problem

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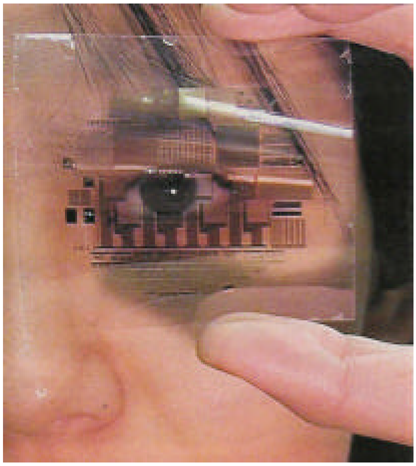
Printed Organic Electronics on Plastic Film



35+ companies

Philips, Plastic Logic, Epson, Canon, Xerox, IBM, PolyIC, OrganicID, Infineon, 3M…

Lower frequencies preferred but increasing

13.56MHz EPC “no compromises” 18 to 24 months.

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Chipless smart labels

2nd generation chipless tags meet EPC data requirements (96 to 256 bits): e.g.

SAW tags (RFSAW and AirGATE Technologies)

Printed Electronics TFTCs: 30 companies

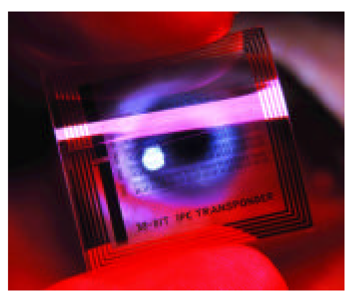
Chipless RFID tags are only about 2% of the RFID market today by value.

They have the potential to reach the lowest

cost and therefore highest volume markets –

barcode replacement and more.

2015 market share may be as high as 45% as these technologies emerge.



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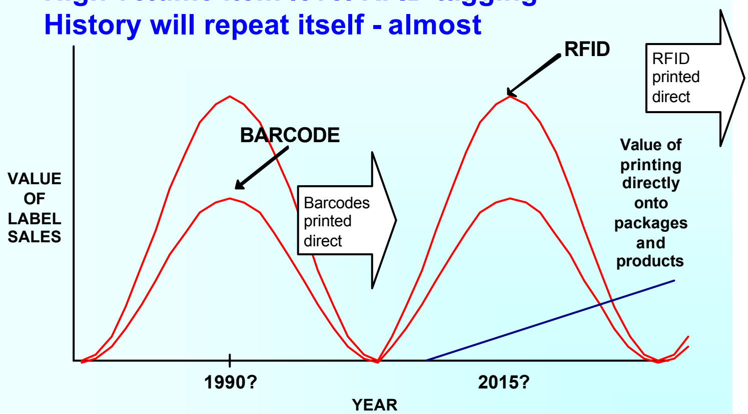
High volume item level RFID tagging
History will repeat itself - almost



The peak in numbers is later

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RFID: the Future

PHASE 1 Conveyances (e.g. pallets) and airline baggage

- Potential 35 billion yearly pallets/cases
- Potential 4 billion yearly baggage/freight

PHASE 2 Item level

- Potential 10 trillion yearly

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Global Potential (Billion/Year)		RFID Leadership
Library	0.1	Singapore
Museums, art galleries	0.1	Europe
National ID cards	0.1	China
Laundry	1	Europe
Animals	1	Thailand, S America, US, Eur.
Tires	1	Europe
Military items	2	US
Blood	2	Europe/US
Test tubes	2	Europe/US
Archiving paperwork	2	US
Air baggage	2	US, China
Air freight	2	US
Drugs	30	US
Pallets, cases	40	US, Europe
Books	50	Japan
Postal	650	Europe
Retail items	10,000	Europe/Japan/US

ITEM LEVEL IN RED

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IDTechEx Forecast for Item Level Tags (Billions)

	2005	2007	2010	2015
Most likely	0.1	1.5	27	800

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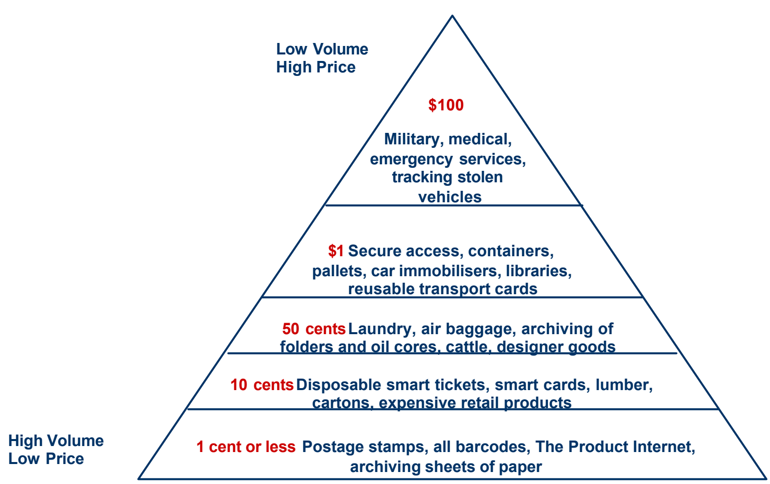
RFID Applications and Potential



Our Forecast For Mainstream Smart Label Systems & Associated Services

(Range over 0.5cm, digitally-encoded)

2015

- $24.47 billion yearly
- 50% tags
- 13% interrogators and smart shelves
- 37% services etc

Chipless includes SAW tags and printed transistor circuits meeting existing standards

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For further information read:

RFID Forecasts, Opportunities & Players 2005-2015

Item Level RFID

The RFID Knowledgebase

Over 1500 case studies listed and growing every month. Covering more than 1650 companies, learn from the successes and failures of others. www.rfidbase.com

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