Wireless Power Transfer and Communication to a Miniature Sensing RFID for Defense

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Driving Applications: Supply Chain Hardware Integrity for Electronics Defense (SHIELD)

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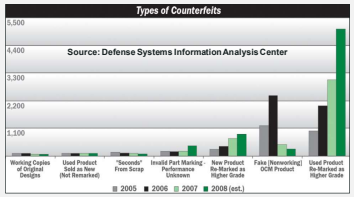
FOR IMMEDIATE RELEASE — Friday, July 8, 2016

Citizen of China Sentenced to 15 Months in Prison for Trafficking in Counterfeit Computer Chips

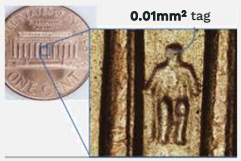
Deirdre M. Daly, United States Attorney for the District of Connecticut, announced that Daofu Zhang, 40, of Shenzen, China, was sentenced today by U.S. District Judge Robert N. Chatigny in Hartford to 15 months of imprisonment for conspiring to sell counterfeits of sophisticated integrated circuits to a purchaser in the United States.

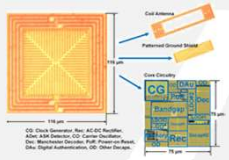


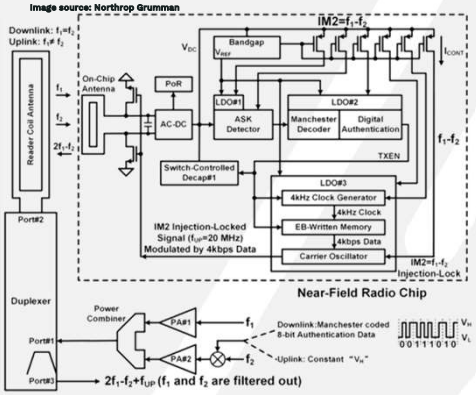
DARPA SHIELD
(Supply-chain Hardware Integrity for Electronics Defense)

- ❑**0.01mm²** tag (with antenna) on critical electronics
- ❑Probe/Reader **1mm** away (Inductive power transfer)
- ❑Report host identity and unusual activity **(Uplink/Sensor)**

First Prototype: A 5.8 GHz Power-Harvesting Dielet with On-Chip Coil Antenna (18' ISSCC)

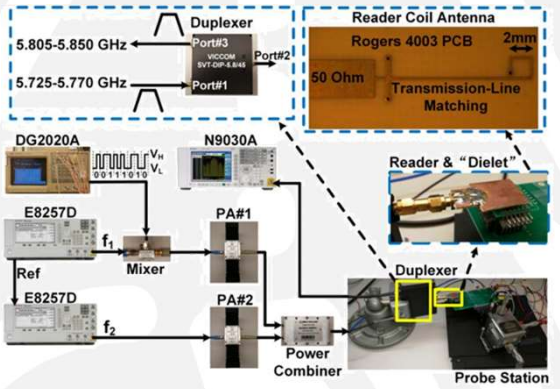






- ❑Coupling distance at 1.0mm
- ❑5.8-GHz RF power = 32 dBm, dc = 10μW
- ❑4kb/s UL with the proposed **IM3 UL** (17' MWCL, 17' TMTT)

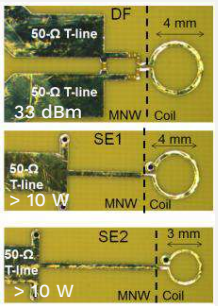
- ❖ Two-tone Tx (5.728/5.768 G) excites the rectifier IM3 current at 5.808 GHz
- ❖ IM3 current modulated by the tag baseband signal (a new UL channel)
- ❖ Closely-separated Tx/Rx frequencies allows passive reuse
- ❖ Tx/Rx frequency separation allows utilization of a **duplexer** for a clean Rx



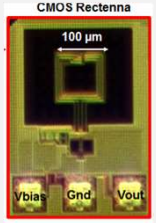
System Optimization and Range Extension with a Differential Reader Coil (18' T-MTT)

- ❑ Analytical expression for IPT PTE developed (variables: coupled-coils geometries, frequency, rectifier stages, material properties)
- ❑ Differential (DF) coil shown to be more efficient than single-ended coil
- ❑ "EM-less" (simulation) numerical optimization locates the optimal design rapidly
- ❑ Best PTE: 4.7-GHz, 33-dBm RF power at **2.2-mm** (PTE = 50ppm)

DF and SE Reader Coils



Rectenna harvested dc = 0.1 mW

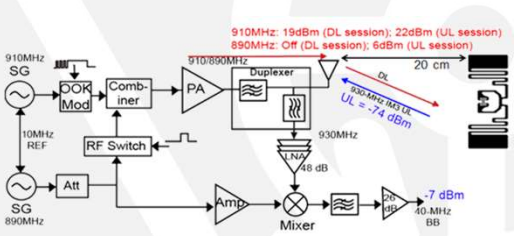


REPORTED IPT PERFORMANCE WITH A MINIATURE TAG (TAG SIZE < 0.2 MM²)

Ref.	Tag Coil (mm²)	Dist. (mm)	RF Freq. (GHz)	Power into Coil MNW (dBm)	dc Power (mW)	RF-RF Eff. (dB)	RF-DC Eff. (dB)	IPT FOM (dB)	Tx Coil	PA Out	Reader Substrate	Integration Level
13' JSSC	0.13	1.0	1.5	17	0.01	N.A	-37	-24	2-Coil	CW	FR4	CMOS Rectenna
16' IMS	0.04	1.1	2.0	21	0.1	-29 (Sim)	-31	-9	2-Coil	CW	FR4	CMOS Rectenna
12' CICC	0.014	0.05	3.5	22	13.7	N.A	-10	-21	2-Coil	CW	Silicon	CMOS Rectenna
16' MWCL	0.01	1.2	4.7	31	0.1	-39 (Sim)	-41	-9	2-Coil	CW	FR4	CMOS Rectenna
16' IMS	0.01	0.5	2.0	N.A	N.A	-27	N.A	N.A	3-Coil	CW	High-R Si	Coils only
17' IMS	0.01	0.5	2.5	20	0.14	N.A	-29	-8	3-Coil	CW	Glass	Discrete Rectifier
This Work	**0.01**	**2.2**	**4.8**	**33**	**0.1**	**-41 (Sim)**	**-43**	**-3**	**2-Coil**	**CW**	**Rogers**	**CMOS Rectenna**

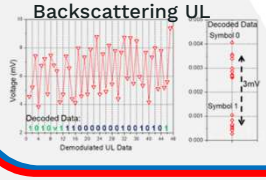
*IPT FOM ≡ (Eff.)× Dist.^{3}/Tag Coil Area$^{1.5}$

IM3 UL Adopted to Far-Field Commercial RFID System (18' MWCL)

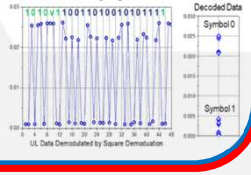


- ❑Improving reader performance communicating to a commercial UHF tag (Monza 6)
- ❑Asymmetric two-tone Tx (910/890 MHz) in UL session
- ❑Decoded IM3 UL EVM (w. square demod.) = -20 dB
- ❑Decoded Backscattering UL EVM (w. IQ demod.) = -14 dB

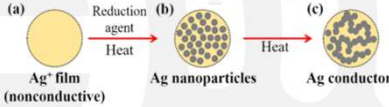
Conventional Backscattering UL



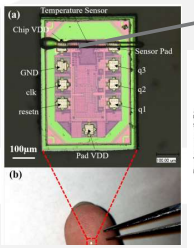
IM3 UL



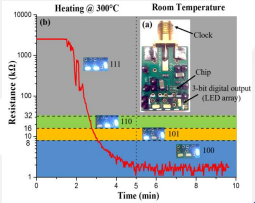
Passive Temperature Shock Recording Sensor (18' MEMS)



- ❑Heating-induced reduction of silver-ions in a polymer film
- ❑Sheet resistance irreversibly drops 4 orders of magnitude in a heating process.
- ❑Deposited to *R*-sensing IC using high-precision electrohydrodynamic deposition technique



Deposited Strip:
length= 200μm
diameter = 30μm



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