

A Scaled, Integrative Implementation for DNA Marking of Integrated Circuits

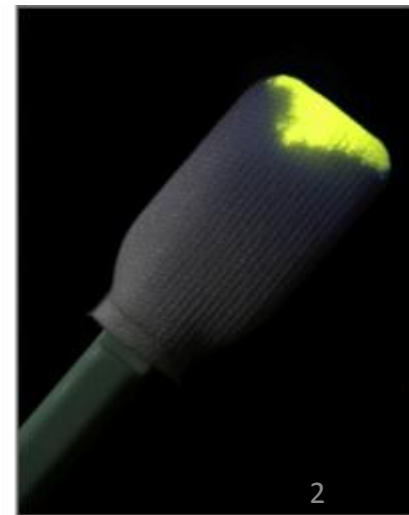
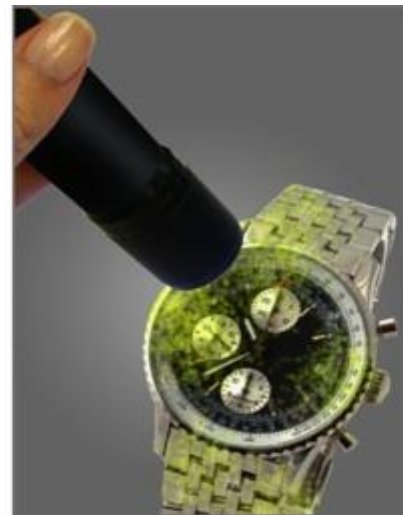
Jim Hayward, Janice Meraglia, Bob MacDowell
18 April 2013

appliednasciences 



Reducing Crime, Fighting Counterfeits, Globally

- Reducing violent cash transport crimes throughout Europe, 57 convictions in UK, 100% conviction rate, >100 cases pending
- Provided covert evidence in 11 serious drug crimes and 6 cases of organized crime in EU
- Deterring bank and pharmacy crime
- Protecting copper wire for utilities and railways
- Protecting Brands against IP Infringement, globally
- Securing jewelry stores in Sweden
- Protecting 2,000 homes against robbery and home-invasion in London



Protecting 2,000 Homes in London's 2 Highest- Crime Boroughs



Marked assets, sting
houses, sting vans
and cars

GULDFYND

“In the year prior to installation, 10 stores experienced 17 armed robberies. The year after, just 3 robberies, for a decrease of 83%.” Leif Svensson, CEO, Safe Solution, Stockholm

Now mandated by:



IF P&C Insurance Company, Ltd.



Swedish Police Service

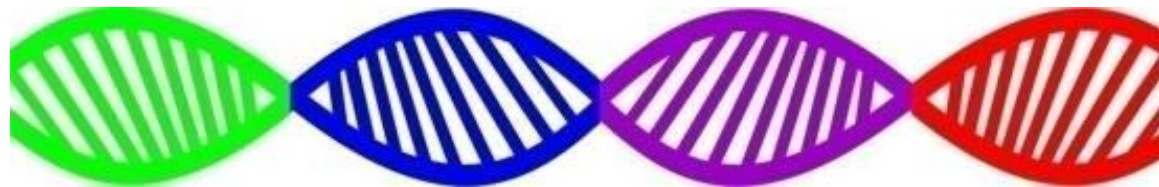
Creating a SigNature[®] DNA Marker



Large Botanical DNA is acquired



DNA is segmented, and encrypted



Segments are shuffled and reassembled to form a unique, secure SigNature[®] DNA marker

Lessons from Paleontology

SigNature[®] DNA.

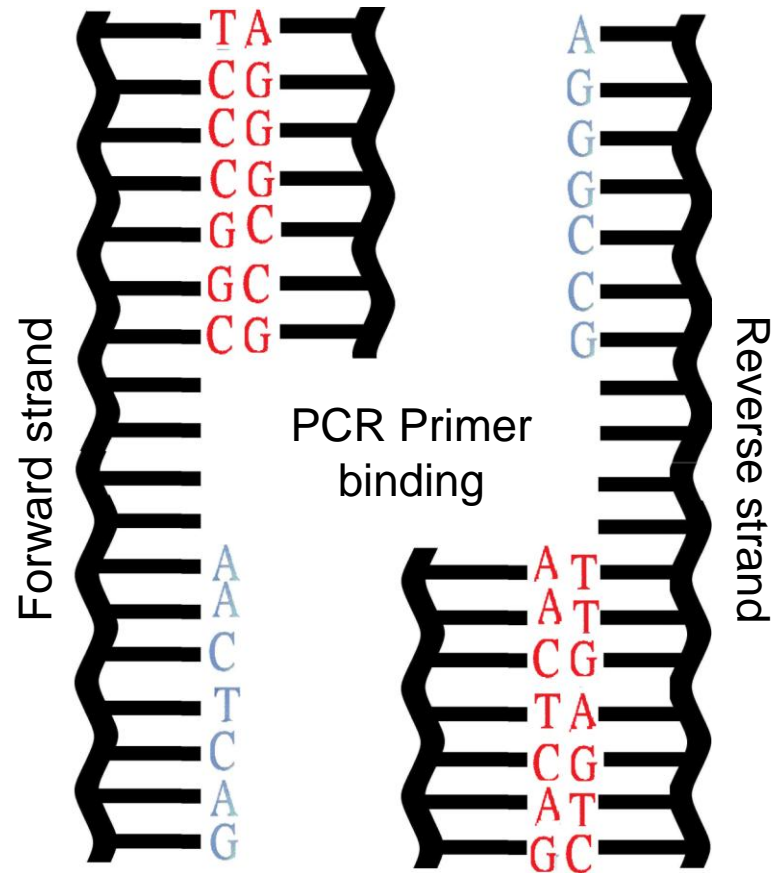


- DNA survives in amber for thousands of years (anhydrous, limited diffusion, etc.)
- APDN mimics these conditions in our chemical hosts
- **Markem-Imaje** mil spec inks ~ amber
- Low DNA concentration

Uncopyable?

First principles:

- Probability of matching any single nucleotide is 1 in 4
- Probability of matching 2 sequential nucleotides is $(1/4)(1/4) = 1/16$
- Probability of matching two 15-base primers is $((1/4)^{15})^2 = (1/4)^{30}$ (**1 in a quintillion**)
- Probabilities radically diminished by multiple marks and decoy DNA



“Copy-Hardened” Optics

Multicomponent Optical-DNA Array

- Interactive optical centers
- Both solid-state and soluble
- Fluorescence pattern is defined by DNA and environment
- “Encrypted” fluorophore revealed by unique APDN test, excludes counterfeit optics
- IR Structured array altered by transfer



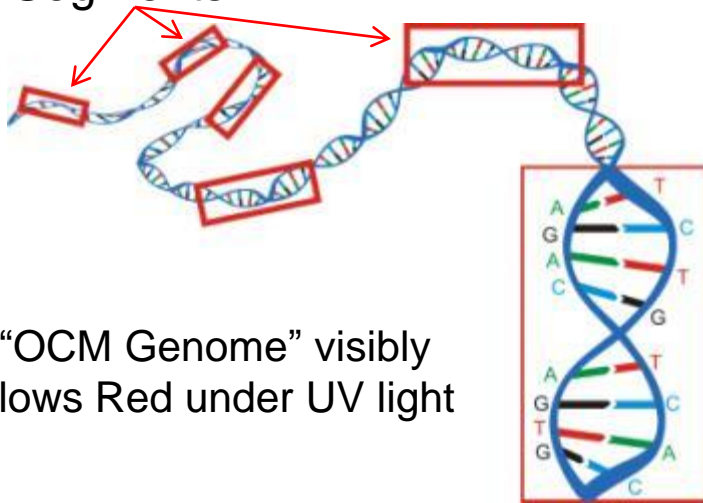
Optics beat the “Red Team” Challenge

UV and DNA Indicates OCM or Distributor Component



**Authenticate Original Components
Marked During Manufacture at OCMs**

Authenticity
Segments



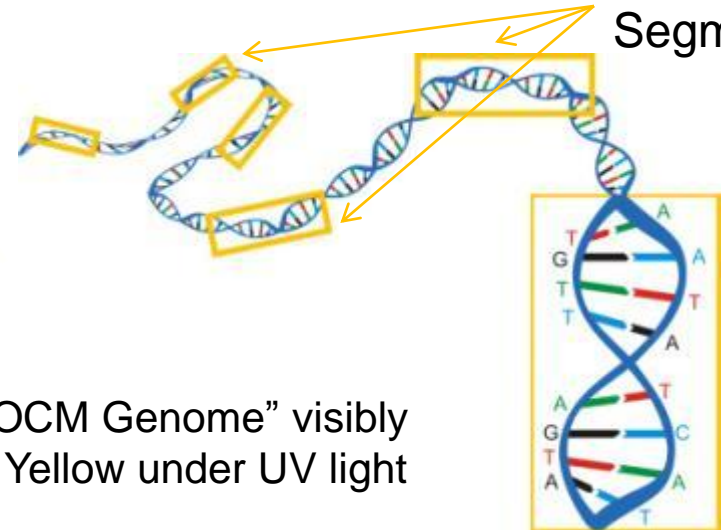
“OCM Genome” visibly
glows Red under UV light

“OCM Genome” unique to each OCM



**Verify Provenance of Distributed
Components Marked After Manufacture**

Provenance
Segments



“Non-OCM Genome” visibly
glows Yellow under UV light

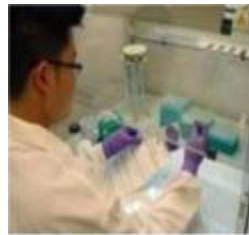
“Non-OCM Genome” unique to each non-OCM

In Field Rapid Screening In Lab Forensic Authentication

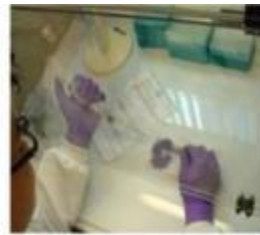


Authenticity
Original
Manufacturers

Provenance
All Others



Label sample is received



Sample Preparation



Purified DNA sample into vial



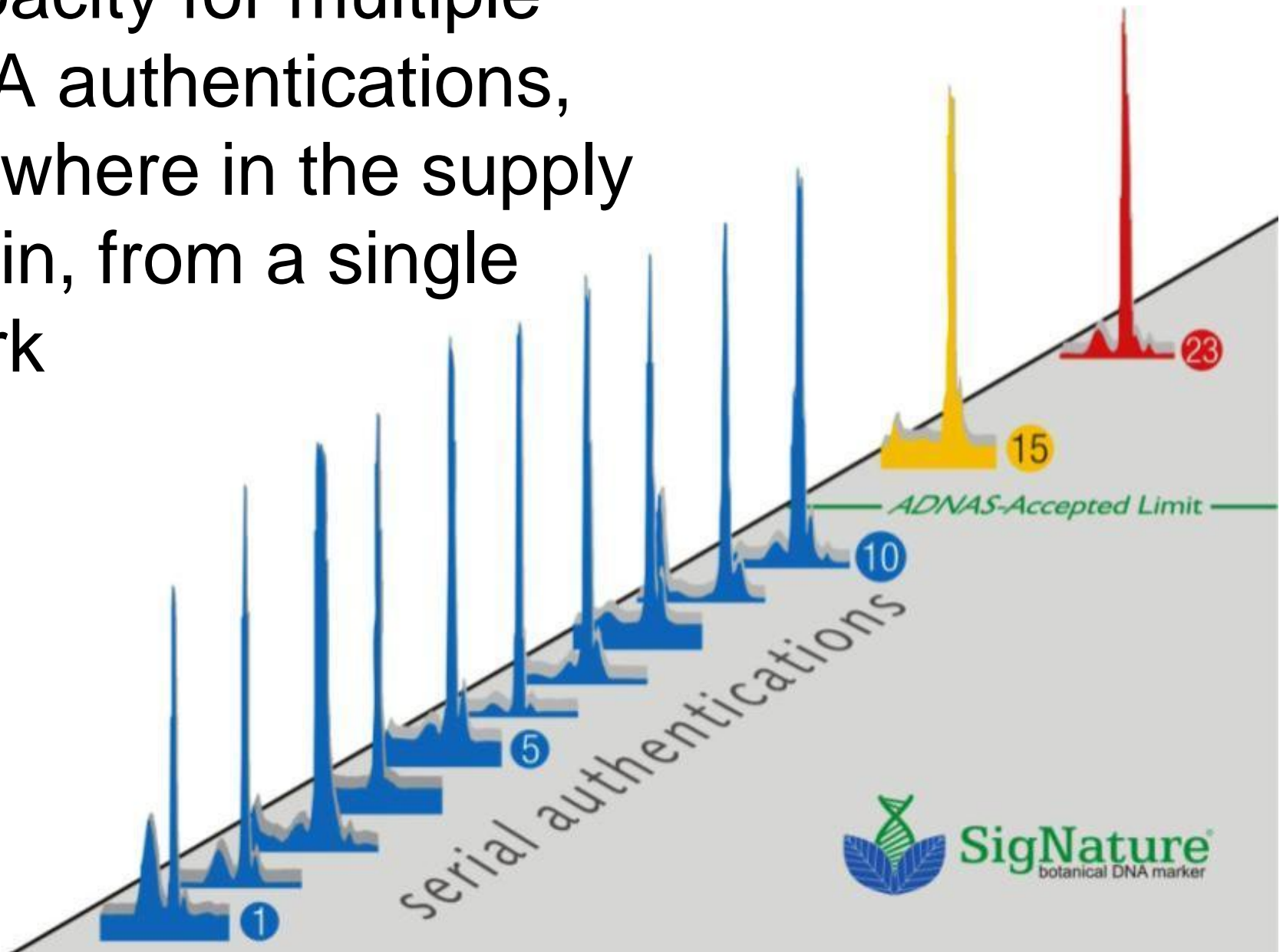
DNA authenticated using PCR machine and/ CE analysis



Results are absolute and definitive

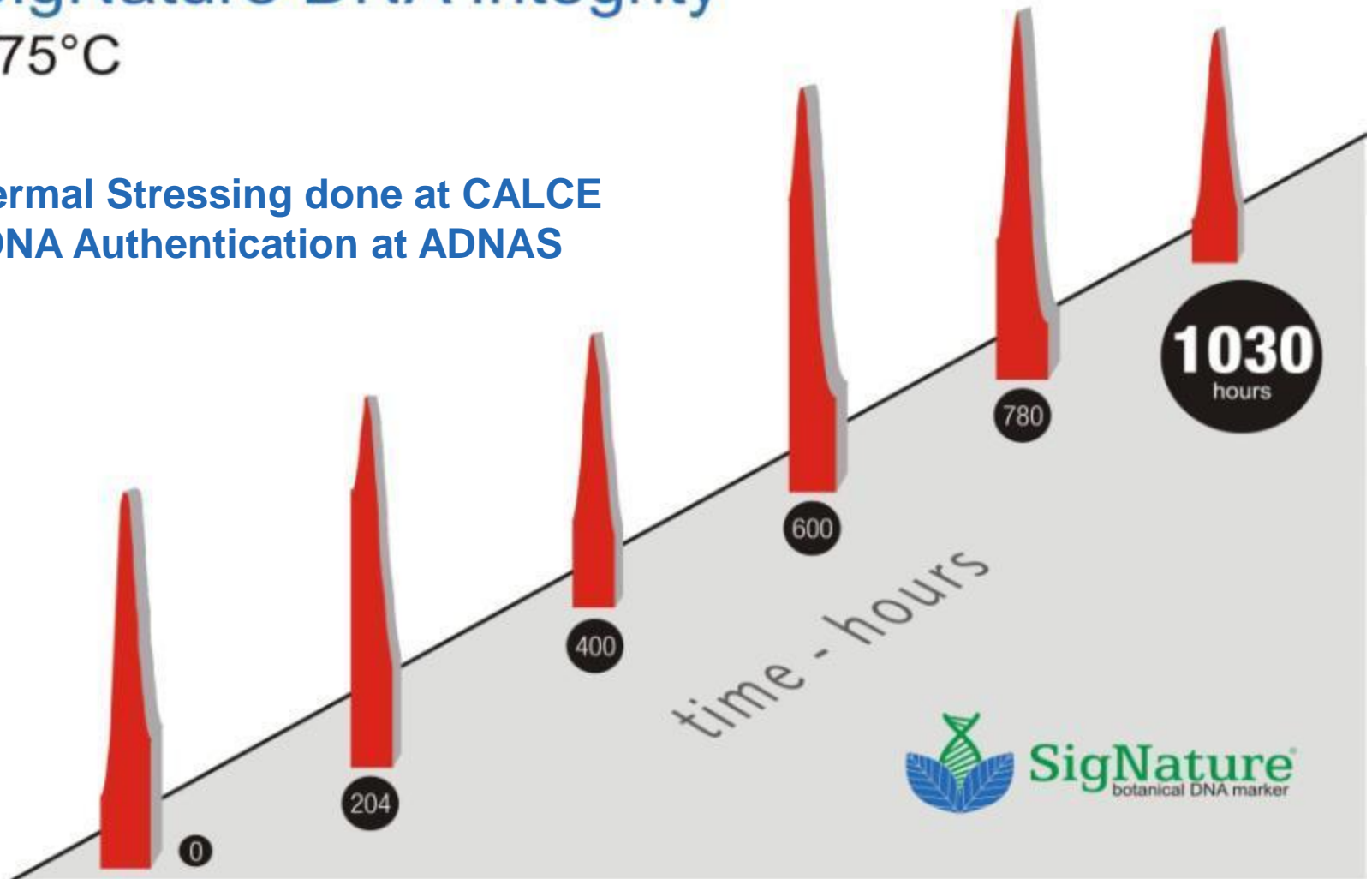


Capacity for multiple DNA authentications, anywhere in the supply chain, from a single mark



Calce Life Cycle Testing: SigNature DNA Integrity 175°C

Thermal Stressing done at CALCE
DNA Authentication at ADNAS



MIL-STD-883 TM 1019.7

- Ionizing radiation (total dose) test procedure

RHA level designator	Radiation and total dose (Rads(Si))	DNA SURVIVES
	No RHA	
M	3000	
D	10^4	
P	3×10^4	
L	5×10^4	
R	10^5	YES
F	3×10^5	YES
G	5×10^5	YES
H	10^6	YES

- * conducted at Aeroflex-rad

SigNature DNA

Tested on metal, ceramic and epoxy surfaces

- Thermal Cycle*
 - MIL-STD-883 TM 1010: **100** cycles, -65°C to +150°C
- Thermal Shock*
 - MIL-STD-883 TM 1011: -65°C to +125°C; 15 cycles
- Unbiased HAST*
 - JESD22-A118, 130°C/85% RH; 100 hours
- Cyclic Moisture Resistance*
 - MIL-STD-883 TM 1004 (+25°C - 65°C, -10°C); **100** cycles
- Resistance to Solvents
 - MIL-STD-883 TM 2015

*Conducted by Silicon Cert Laboratories without applied voltage.

SigNature DNA

Tested on metal, ceramic and epoxy surfaces

- Simulated wave solder immerse in solder*; JESD22-B102E, Sn96.5Ag3.0Cu0.5, at 245° C for 5 seconds
- Simulated solder reflow solder*; JESD22-B102E reflow at 260°C
- Ten X-ray exposures*; MIL-STD-883 TM 2012 Radiography
- Salt Atmosphere*; MIL-STD-883 TM 1009 Condition D, 35° C, 240 hours
- Resistance of Insulating Surfaces** ASTM D-257 07 Sample exceeded the measuring capability of the Megaohmmeter. Surface Resistivity (Ω /square) is greater than 5.24E+15; SigNature DNA is non-conductive

*Conducted by Silicon Cert Laboratories without applied voltage.

**Conducted by Intertek

SigNature DNA

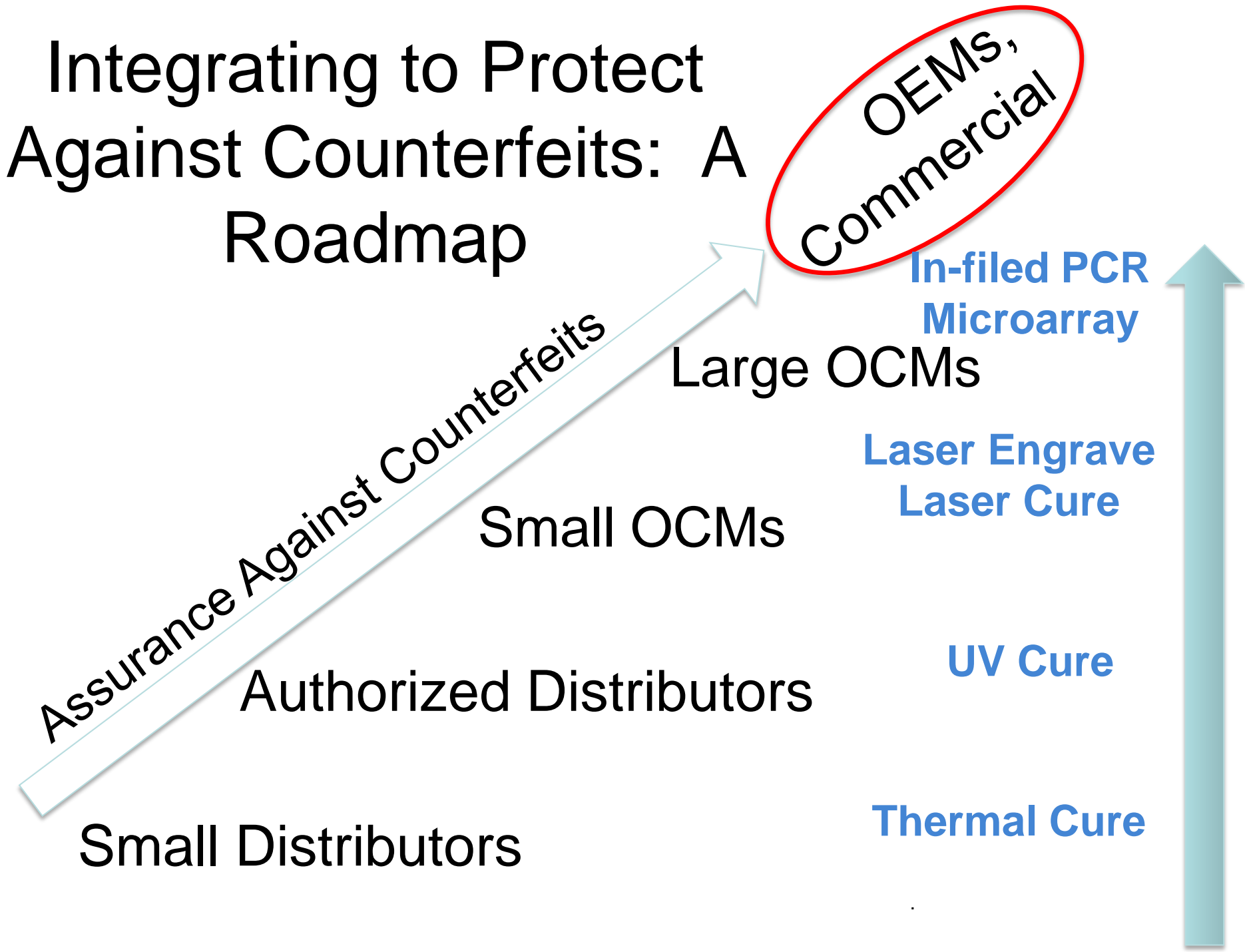
Tested on metal, ceramic and epoxy surfaces

- **Outgas Testing*****; ASTM E 595, Vacuum < 5×10^{-5} torr – 24hrs @ 125°C, DNA falls 30-80% below the rejection criteria
- **Non nutrient for fungus******; **MIL-STD-810G METHOD 508.6**: Resistance to Fungus Test; all SigNature® DNA-embedded inks are **NEGATIVE** in 28 day test

***Conducted by Pacific Testing Laboratories

****Conducted by APDN Laboratories

Integrating to Protect Against Counterfeits: A Roadmap

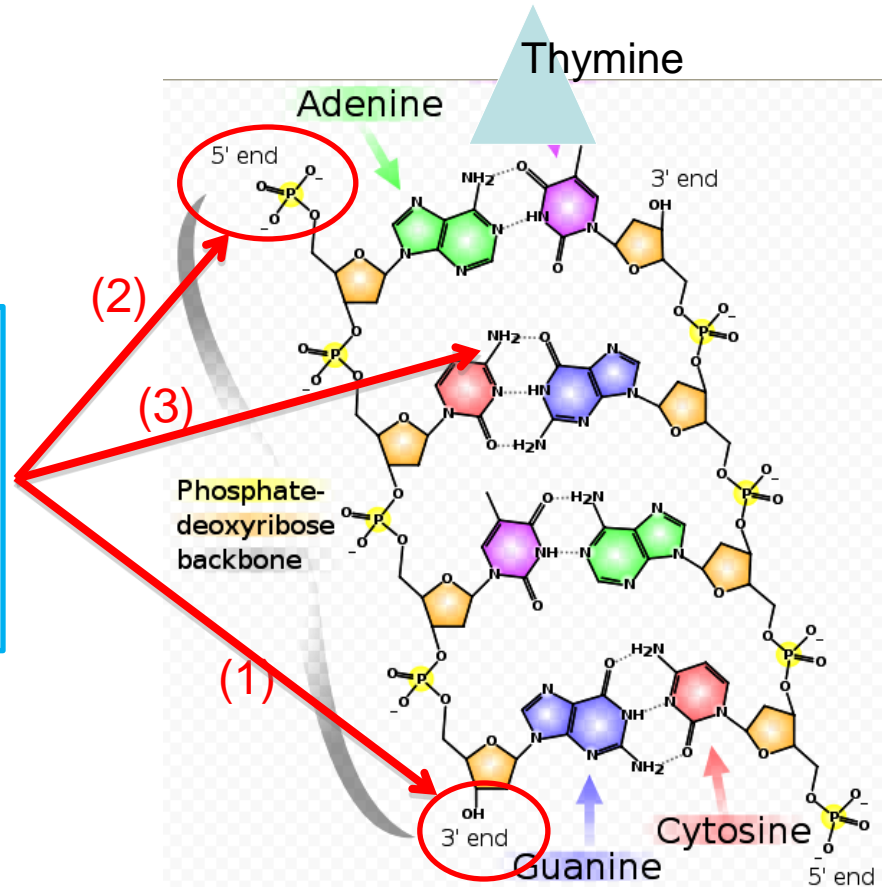


Integrating Scale, Timing and Evolving Methodologies to Service All Manufacturers and Distributors

SC Business Category	1 Small Distributors	2 Large, Authorized Distributors	3 Small OCMs	4 Large OCMs
Scale of daily production	Small batches: 100s or less 1,000s	1,000s 10,000s	10,000s 100,000s	Millions
Type of Epoxy Ink All Milspec All thoroughly tested to Jedec standards	Clear	Clear	White, black or colored	NONE
Type of Cure	Thermal	Thermal/UV	UV	Covalent Coordinated Complex with Existing Package
Type of Print	Hand Small scale Pad Printing	Small Scale PP Large Scale PP	Large Scale PP	Laser Engraving
Source of Service	3 rd Party (preferred) In house	3 rd Party In house	In house	In house
DNA Carrier	Clear Epoxy Ink	Clear Epoxy Ink	Pigmented Ink	None
Method of DNA Implantation	Ink	Ink	Ink	Plasma Deposition, Laser-Activated Deposition
Type of SigNature DNA Mark	Provenance	Provenance	Authenticity	Authenticity

DNA Binding Sites Available for Binding to Laser-(Plasma)-Activated Substrates on IC Packages

- Available binding sites:
1. 3' end (OH)
 2. 5' end (PO_4^{2-})
 3. Amines (NH_2)

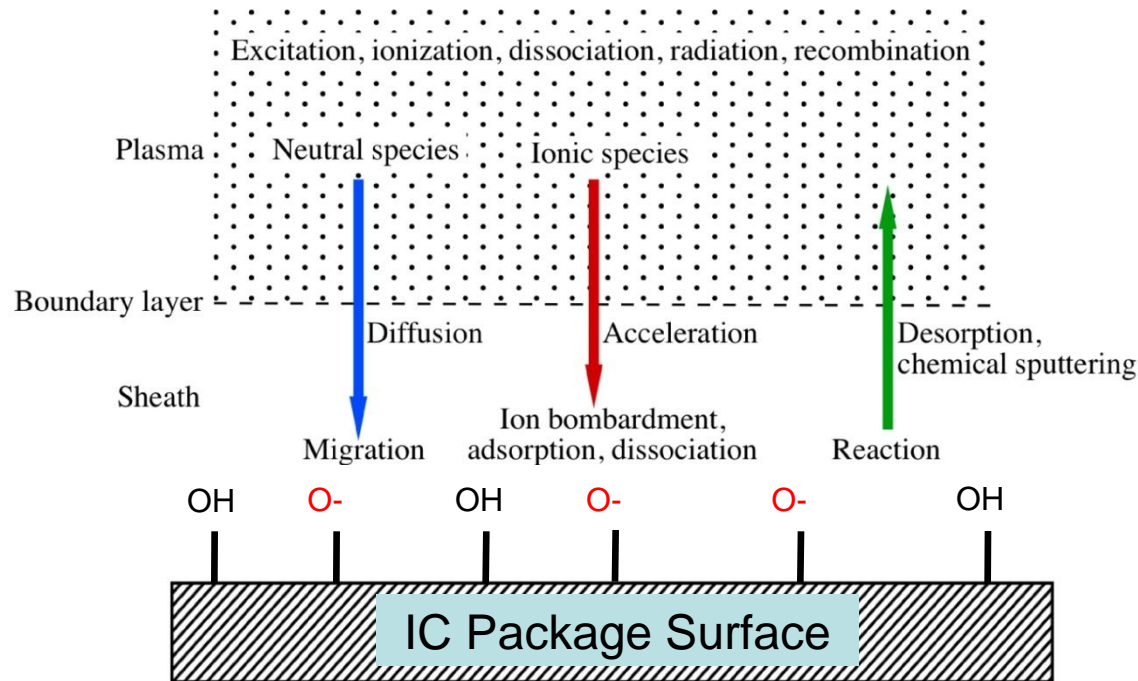


Prosthetic Reactive Sites on Package Substrates Available for DNA Binding

Substrate	Reactive group
Ceramics, silicates glasses	OH
Polyamines, Nylon	NH and O
Polyesters	C=O
Acrylic	C \equiv N
Amorphous Solid Polymers (Nylon, Polyesters, PP, PS, PET, etc...)	CH ₃
SiO ₂ (Silicon dioxide) or Si ₃ N ₄ (Silicon Nitride)	O or N

Many of these reactive sites become available on package surfaces upon plasma or laser activation.
Can be integrated with Laser Engraving.

Laser Functionalization During Engraving



1. Laser-induced plasma engraves the surface.
2. Laser-induced plasma is responsible for the increase in polar groups.
3. Polar groups create adhesion properties on the polymer surface.
4. DNA can bind to various IC package types via different reactive groups.

Laser Engraving Should Enhance DNA Binding



Surface of integrated circuit package during laser engraving

- Laser induced plasma activates the IC surface during engraving
- Process as practiced by industry will produce prosthetic reactive groups that will bind DNA
- Little or no alteration of current engraving process
- APDN already demonstrated DNA binding via plasma to assorted plastic, ceramic and metal surfaces
- Patents pending

In Field PCR Analysis

- Driven by the need for bed-side diagnostics and first-responder capacity for bioterrorism.
- Microfluidic chips accelerate PCR and condense time frame to just minutes.
- In series microarray can identify up to 10,000 specific DNA taggants.
- All IC SigNature DNA markers can be detected with a uniform kit and a proprietary primer.
- Several companies are expected to market a portable Microfluidic PCR-Microarray DNA identifier within 12-24 months.
- Would allow forensic detection of SigNature DNA Authenticity and Provenance marks in field with minimal training

Case Study: An Early Adopter Uses SigNature DNA to Secure DOD Supply-Chain and Rack up ROI



*By Bob MacDowell
Applied DNA Sciences, Inc.*

The electronic component industry remains infested with counterfeit components. Short life cycles for components used in long-term military projects force OEMs to wade out into the murky waters of the 'open market' to procure obsolete parts. Shifting demands cannot always be predicted by the authorized channels, leading to unacceptable lead times, exacerbating the supply challenge.

*** Over 5,000 5962 microcircuits DNA Marked
and shipped to DLA as of April 2013**

Applied DNA Sciences

Thank you!

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