



## Large-Scale Print-Manufacturing of Complex 3D Structures

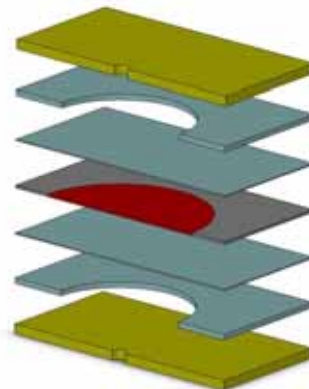
Arthur L. Chait  
CEO, EoPlex Inc.  
Feb. 10, 2010

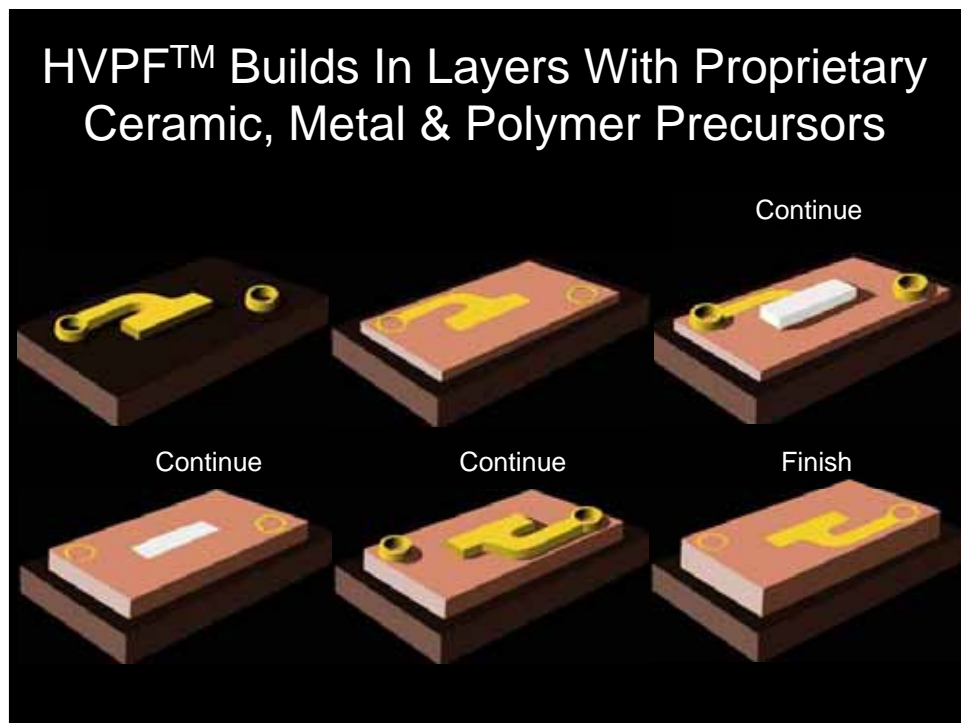
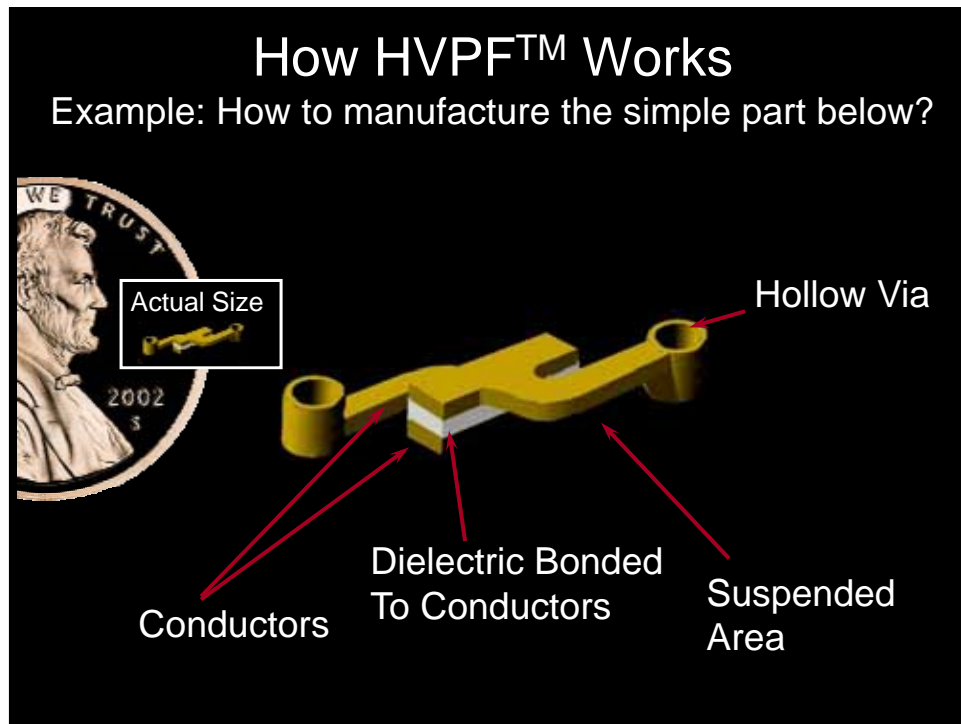


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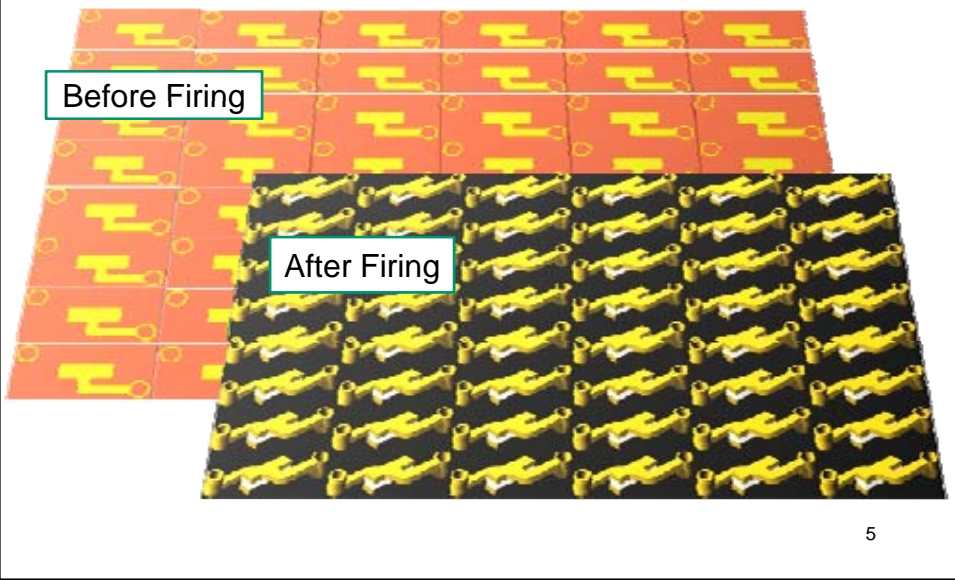
## High Volume Print Forming (HVPF™)

- Layered process, but NOT rapid prototyping
- Uses metals, ceramics & polymers
- Material combinations & metastructures
- Low cost and clean-technology
- Increased design freedom
- Produces thousands of parts at once



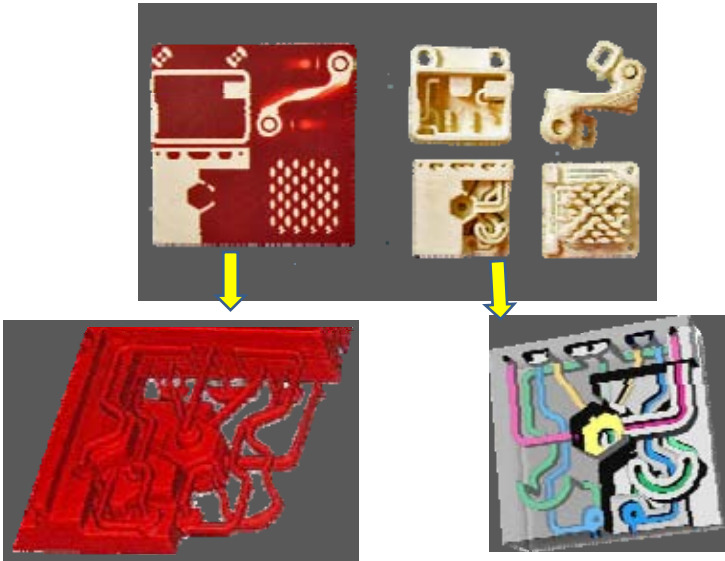


# HVPF™ : Panel Processing: 1,000s Of Parts At Once = Low Cost



# Almost Any Material & Any Shape

Block: 4 parts, 200 layers, 60 feature-layers red is fugitive



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## EoPlex Basic Design Rules

### Device Dimensions

Min. length	1mm
Max. length	200 mm

### Feature Dimensions Minimums

Standard Process	
High Aspect Ratio Features	200 $\mu$
Thick Planar Features	50 $\mu$
Extended Process	25 $\mu$
Feature Tolerance	$\pm 0.5\%^*$

### Layer Characteristics

Materials/layer (typical)	2 to 5
Typical layer thickness	5 $\mu$ to 500 $\mu$
Min. layer thickness	3 $\mu$

\* none less than 10 $\mu$



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## EoPlex Current Catalog Of Materials

### Ceramics

- Glass-ceramics
- Piezoelectric materials (PZT)
- Oxides: Alumina ( $\text{Al}_2\text{O}_3$ ), silica ( $\text{SiO}_2$ ), zirconia ( $\text{Zr}_2\text{O}_3$ )
- Custom low loss dielectrics

### Metals

- Structural metals: Nickel alloys, stainless steel, iron
- Conductors: Palladium, silver, gold, platinum

### Polymers with and without fillers

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# HVPF™ FAB: Small, Low Cost & Easily Located Along Customer's Supply Chain



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## Typical Applications Where HVPF™ Provides Customer Benefits



Ceramic Antennas



Semiconductor Packages



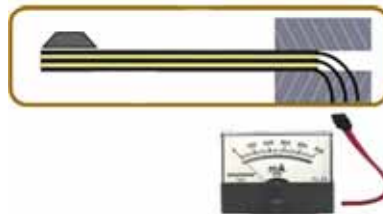
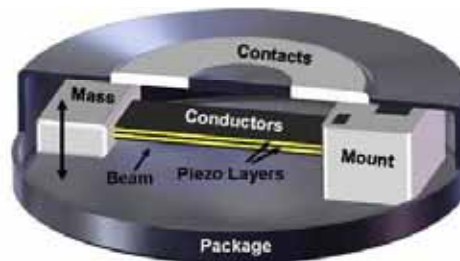
Energy Harvesting



Fluidic Components

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## With HVPF™ PZT Energy Harvester Can Be Produced At Price = Battery



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## Fluidic Parts: Complexity At Low Cost 300 Layers, 33 Features, 5 Different Materials



Methanol Reformer



- Channels
- Chambers
- Ports
- Catalysts
- Metals
- Ceramics
- Fugitives

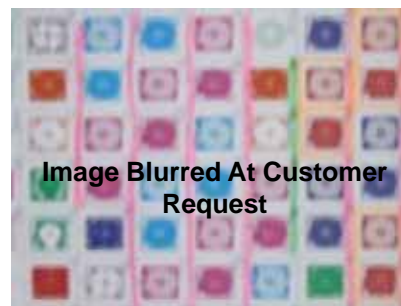


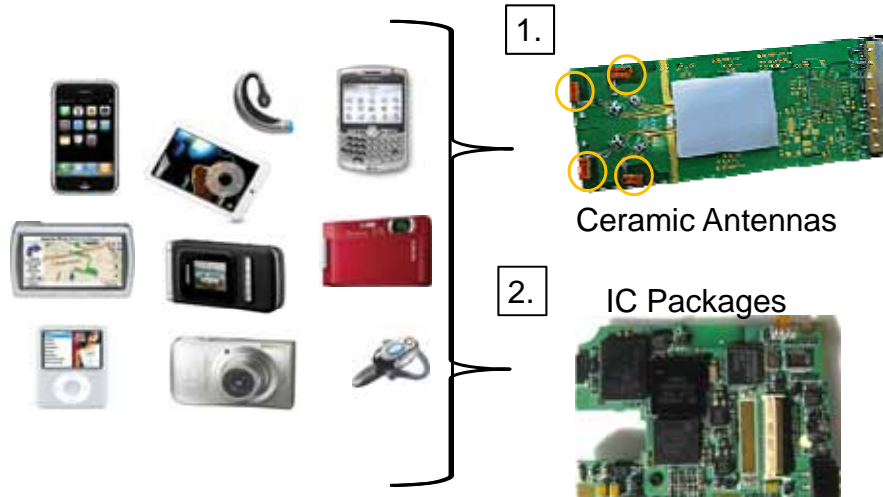
Image Blurred At Customer Request



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## IC Packages And Ceramic Antennas Are Ideal Applications Of EoPlex



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## Early Cell Phones Had One External Antenna

External antennas:  
worked well but limited  
design



Internal antennas:  
better design but took  
too much space



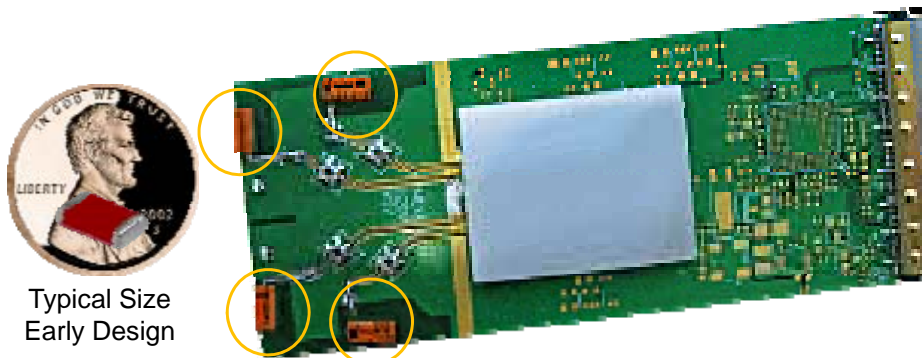
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## Today Cell Phones Use Lots of Antennas and Space Is Critical



## Ceramic Antennas Solved Space Issue

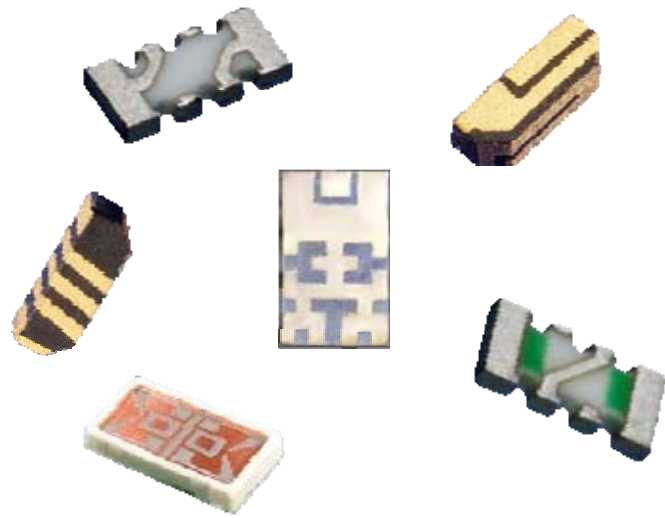
Early Designs Were Easily Manufactured  
By Conventional Ceramic Techniques



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# Growth In Cell Phone Applications Created Demand For More Complex, Small Antennas



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# HVPF™\* Was Identified By Antenna OEMs As A Process To Fill The Gap

Process Features	Form-Fire & Metalize	Tape Process LTCC	EoPlex (HVPF™)*
3-D Design Flexibility	Limited 	Limited 	High 
Internal Connections	No 	Punched Vias 	Unlimited 
Internal Features	Very Limited 	Yes 	Yes 
Materials Flexibility	High 	Limited 	Yes 
Multiple Materials	Very Limited 	Limited 	Yes 
Metamaterials	No 	Very Limited 	Yes 

\*High Volume Print Forming (HVPF™)

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## HVPF™ Antennas Are Being Built With Better Performance In Smaller Package

### Tech. Advantage

Advanced Designs

Materials Freedom

Internal Features

3-D Structures

Metastructures



### Customer Benefit

High Efficiency

Wide Bandwidth

Low Cost

Small Size

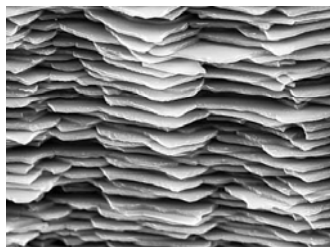
Multiple Antennas  
on One Chip



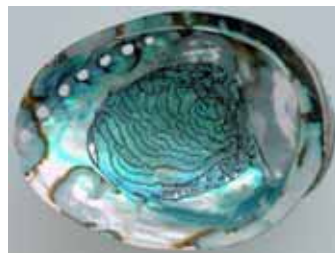
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## Metamaterials

A material that gains its properties  
from structure rather than directly  
from composition



Nacre



Mother of Pearl

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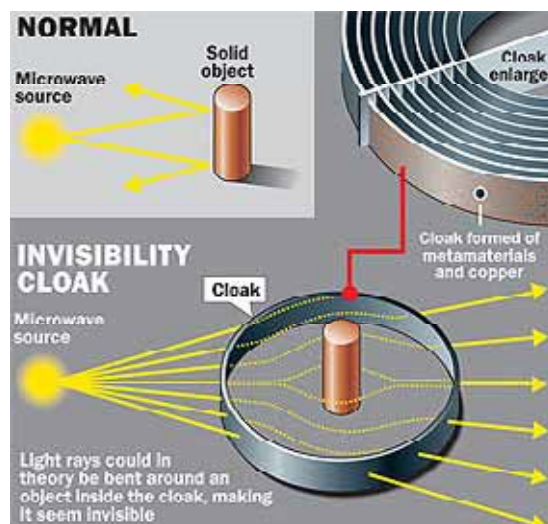
## Lots Of Interest In Using Metamaterials To Create Real Cloaking Devices

**Star Trek:** Klingon Bird-Of-Prey Warship



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## **Reality:** Dr. Smith At Duke Demonstrated 1<sup>st</sup> Successful Device



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## HVPF™ Voxel Deposition\* Can Produce Micron-Level Metastructures

- Voxel is like a tiny Lego® block



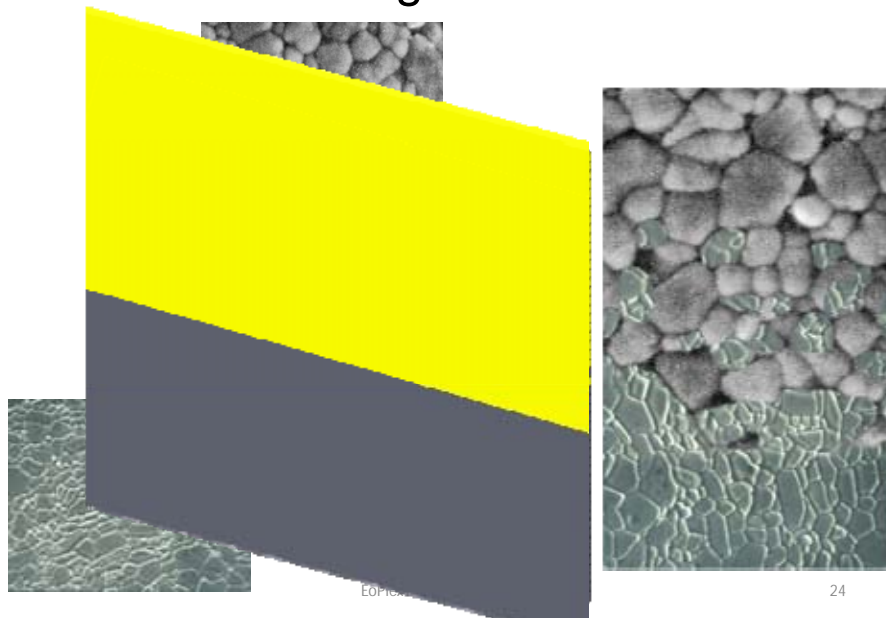
Lego ® Einstein

- HVPF™ builds in voxels\* - microbricks
- Voxels of different materials = metastructure
- Several applications

\* Patent pending

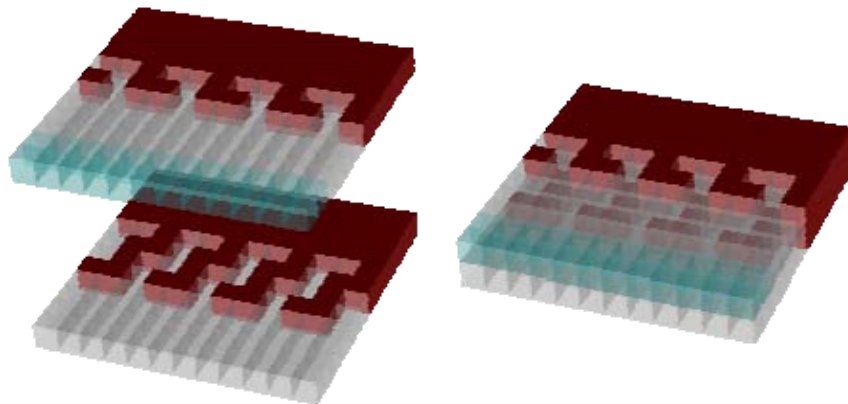
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## Metastructures: Engineered Transitions



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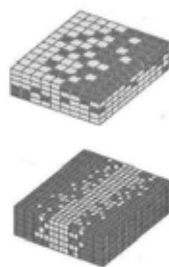
## Voxel Deposition With HVPF™ Allows Engineering At the Microstructure Level



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## Metastructures Can Overcome Some Material Mismatches

Conventional

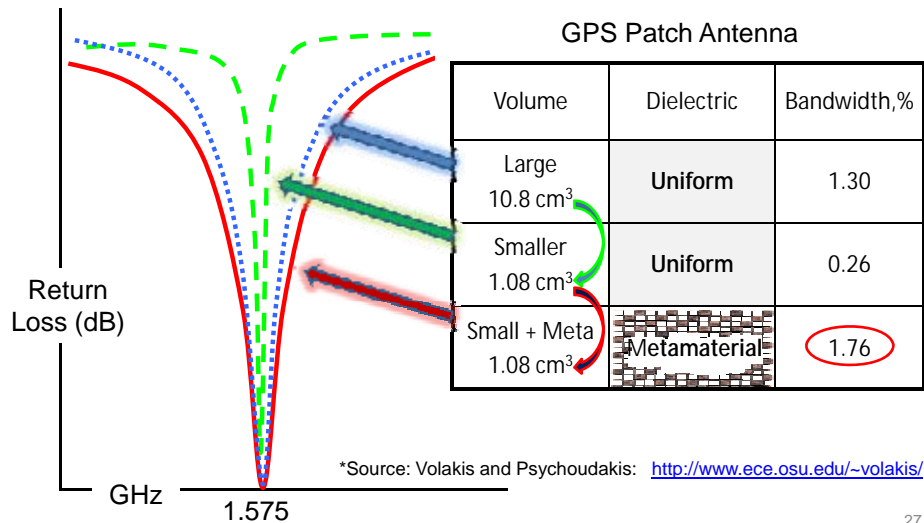


EoPlex



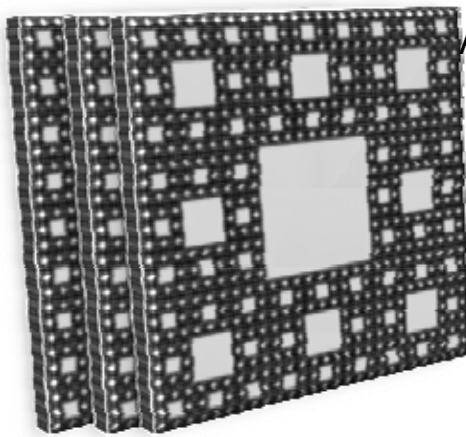
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## Metastructures Offer The Potential To Increase Bandwidth In Small Antennas \*



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## HVPF™ Solves Mfg Of Metastructures Challenge: How To Optimize Designs



Almost Too Much Design  
Freedom

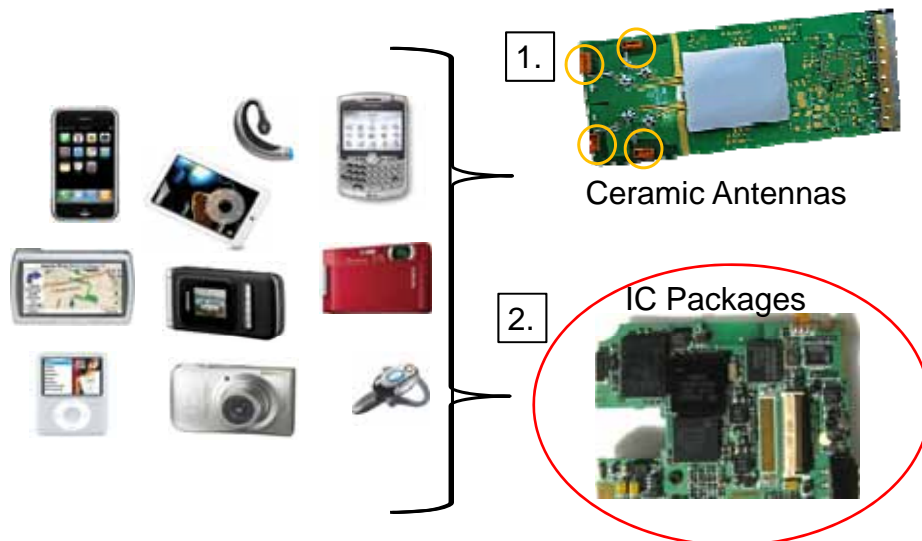


- Voxel shape
- Voxel size
- Pattern in X, Y, Z
- Open spaces
- Chemistry
- Grain size
- etc.

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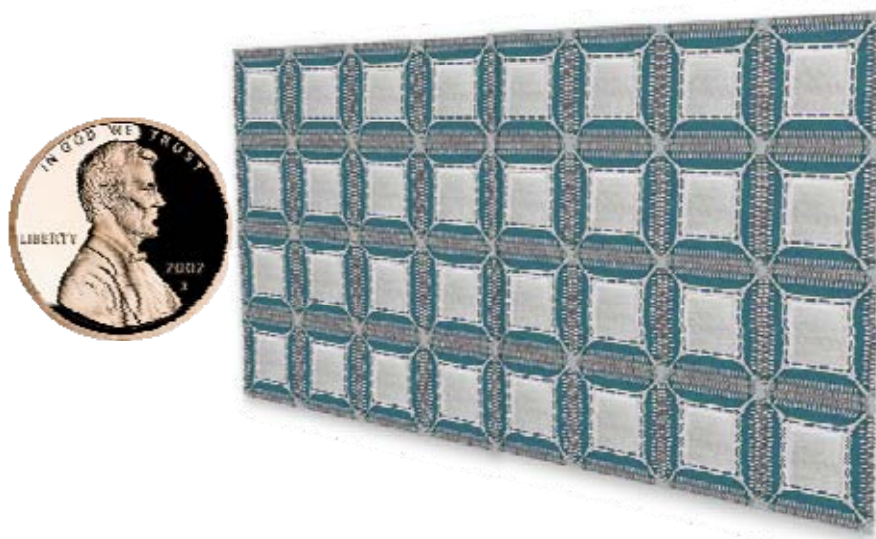


## IC Packages For Portable Electronics



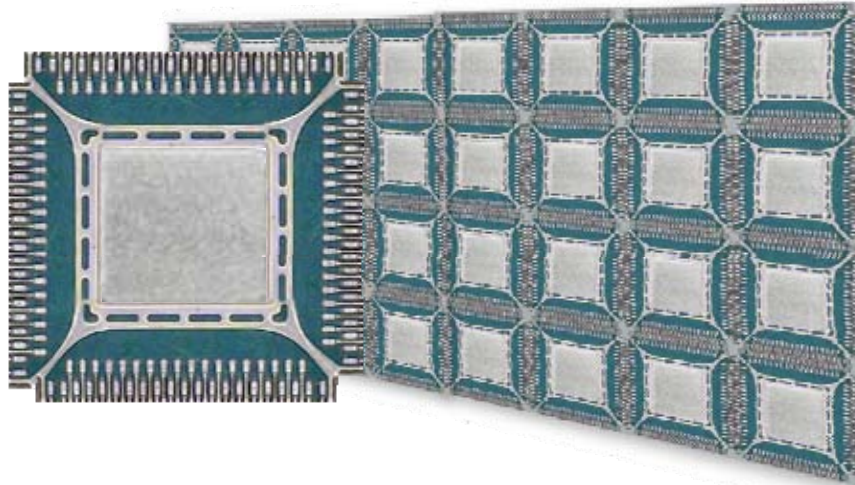
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## QFN-Type Lead Frame: Favored For Many Applications, But Limited

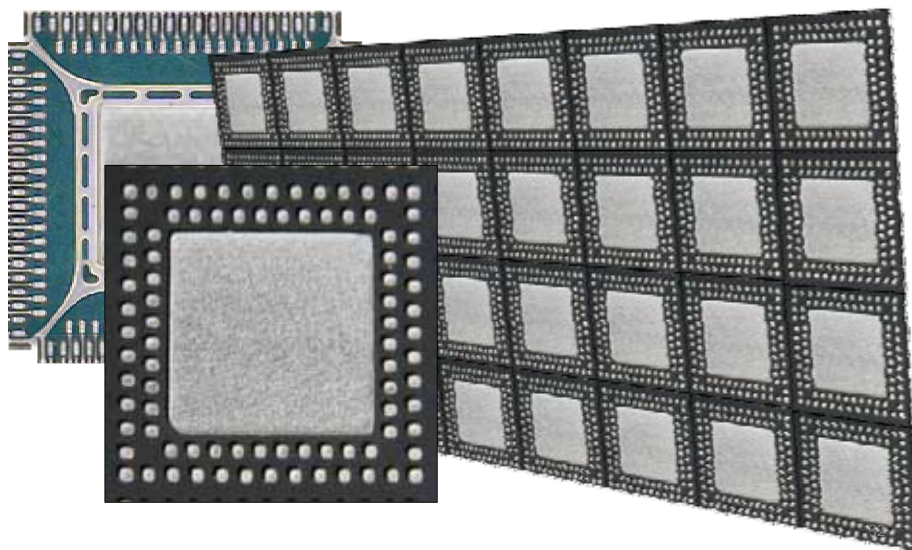


## Limitations

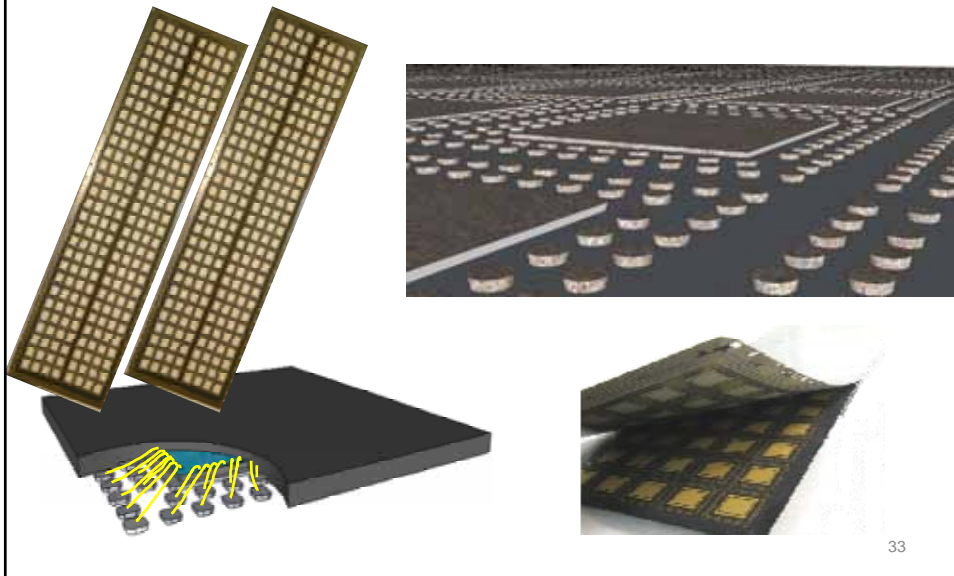
Pin Count - Extra Metal = Lower Performance  
Testing Cost - Plating & Etching Processes



Needed: A New Type Of Lead Frame  
Without These Limitations

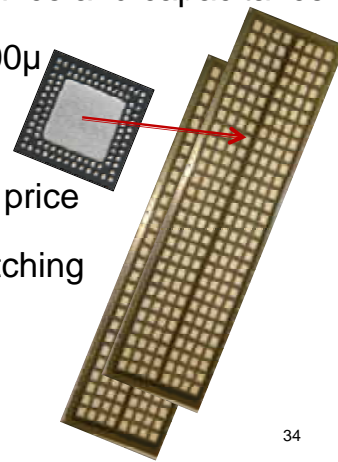


## HVPF™ Allows A Sintered Substrate Of This Type To Be Produced At Low Cost



## EoPlex New Package Substrate Will Be Introduced In Q2

- Low package volume and high lead count
- Min. metal necessary = min. inductance and capacitance
- Lead counts >500, pitch down to 300μ
- Testing and dicing cost reduced
- Lower cost package = lower device price
- Clean-tech process, no plating or etching



\*Patent-Pending

## Summary

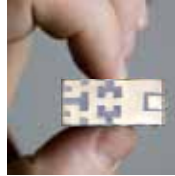
### HVPF™ A Clean, Low Cost Way To Produce High Performance Parts



Clean-Tech  
Process



Lower Cost



Smaller Size &  
Better Designs



Higher  
Performance

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Thank You  
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