Earth Tested – Space Proven!

Is it true that

Smaller Can Be Better?

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What is this poster session about?

- ✓ *The use of proven temperature stable, custom ceramic materials that do not age, or outgas and are Rad Hardened for use in Space.*
- ✓ *These DLI materials are 'EAR 99' substrates.*
- ✓ *Space requires components that are capable of 'SWAP' (Size, Weight and Power reductions and extreme stability.*
- ✓ *DLI custom materials are high 'K' allowing size reductions up to 15 times that of PWB materials*
- ✓ *Temperature Stability is >10 X better than conventional materials, temperature guard banding over -54C - +125C*

CERTIFICATE OF REGISTRATION

This is to certify that

Dielectric Laboratories, Inc.
2777 Route 20 East, Cazenovia, New York 13035 USA

operates a

Quality Management System

which complies with the requirements of

ISO 9001:2008 + AS9100C

The above organization has been audited in accordance with the requirements of AS9104A.
SAI Global Certification Services Pty Ltd dba QMI-SAI Canada Limited located in Toronto, Ontario, Canada is accredited by ANAB under the Americas Registration Management Program.
The certificate is issued at the accredited location in Toronto, Canada.

for the following scope of registration

The registration covers the Quality Management System for the design, manufacture, and delivery of capacitors, built to print thin film products and proprietary thin film components for high frequency applications.

Certificate No.: CERT-0056368
File No.: 006818

Original Certification Date: March 21, 2009
Current Certification Date: March 20, 2012
Certificate Expiry Date: March 19, 2015

Chris Jouppi
President,
QMI-SAI Canada Limited

Alex Ezrakhovich
General Manager,
SAI Global Certification Services Pty Ltd

Certified System
AS9100C

ANAB ACCREDITED

Registered by:
SAI Global Certification Services Pty Ltd, 286 Sussex Street, Sydney NSW 2000 Australia with QMI-SAI Canada Limited, 20 Carlson Court, Suite 100, Toronto, Ontario M9W 7K6 Canada (SAI GLOBAL). This registration is subject to the SAI Global Terms and Conditions for Certification. While all due care and skill was exercised in carrying out this assessment, SAI Global accepts responsibility only for proven negligence. This certificate remains the property of SAI Global and must be returned to them upon request.
To verify that this certificate is current, please refer to the SAI Global On-Line Certification Register www.qmi-saiglobal.com/qmi_corporate/

SAI GLOBAL

The Secret Sauce

- >100 proprietary or patented ceramic formulations fabricated from powders at DLI
  - K values as low as 4 to more then 30,000
- 'Ultra Stable' Temperature Coefficient of Frequency (TCF)
  - 'CF' Ceramic (K23), 0 ± 15ppm/°C - Typical Average TCF ≤ 5ppm/°C
  - Compared to Alumina , @120 ± 30ppm/ °C Typical Average TCF = 50ppm/°C)
    - 10x improvement
  - High K ceramic dielectric (K~23) offers
    - 15x size reduction over PWB materials (K~3.5 to 4)
    - 2x size reduction over Alumina (K ~ 9.9)
  - CF doesn't exhibit signs of aging (used in DLI Caps for decades).
  - CF doesn't out-gas in a space environment due to its dense nature
  - Radiation Hardened (1 Mega-Rad total dose no performance degradation).
- Optimized Material, Design and Process Technologies to produce unique products

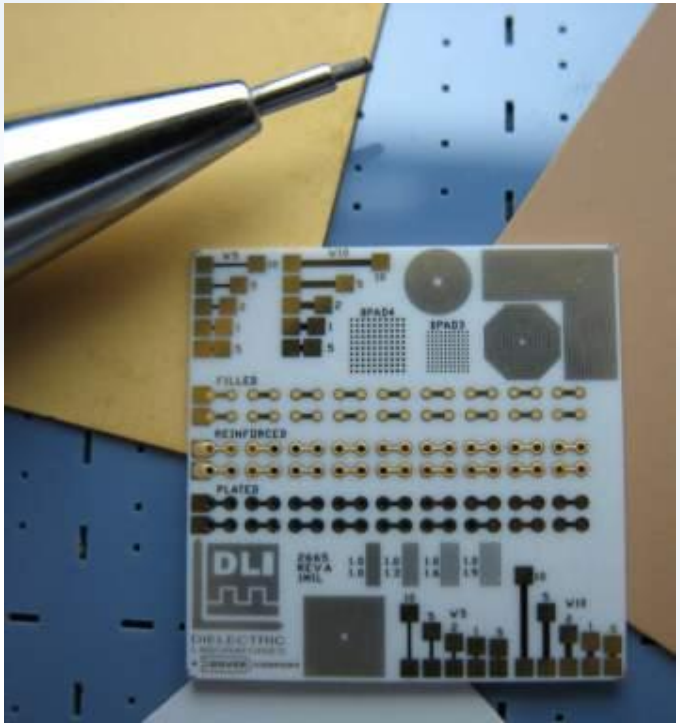
Materials for Temperature Stability

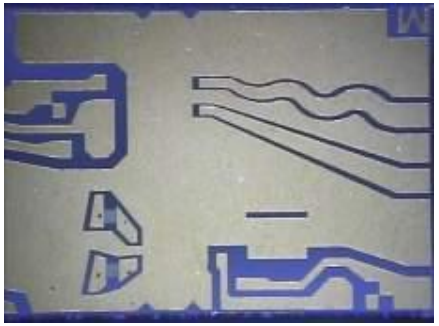
Substrate Material	Dielectric Constant (Tolerance)	Typical Loss Tangent	Coefficient of Thermal Expansion (ppm/°K)	Temperature Coefficient of Capacitance (ppm/°C)	Surface Finish (m-inch)	Temp Stability
99.6% Alumina (Al2O3) PI	9.9 (± 0.15) @1MHz	0.0001	6.5-7.5	P120 ± 30	<5	Poor
PG	**12.5 (± 0.5)**	**0.0002**	**7.6**	**P22 ± 30**	**<5**	**Good**
CF	**25 (± 2)**	**0.0003**	**9.0**	**0 ± 15**	**<5**	**Excellent**
CD	**38 (± 1)**	**0.0004**	**5.8**	**N20 ± 15**	**<5**	**Good**
CG	**67 (± 3)**	**0.0008**	**9.0**	**0 ± 30**	**<5**	**Very Good**

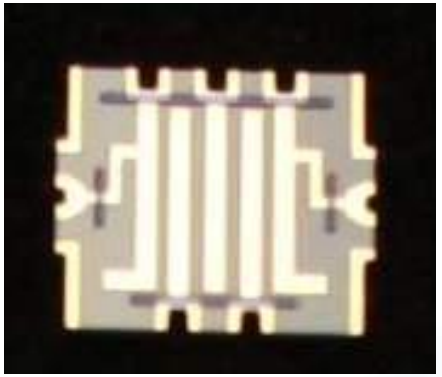
Benefits of High K Ceramic Substrates

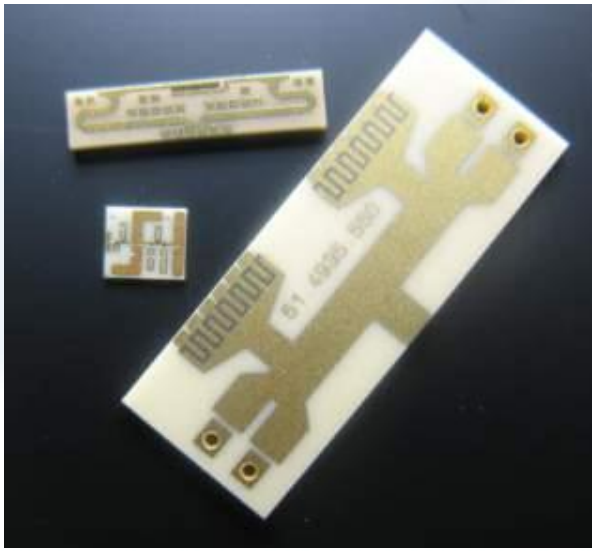
- *Size reduction - Reduced area = Reduced cost – smaller and lighter systems*
- *Thin Film precision = excellent repeatability and no tuning*
- *Improved field confinement =*
  - *Higher Isolation, Higher Q, Lower Insertion Loss*
- *Improved temperature stability – guard banding for frequency drift unnecessary*
- *Lower CTE mismatch stress in surface mount applications – more reliable*
  - *Smaller size – less stress*
  - *CTE 9.5ppm/°C (Expansion Coefficient Alumina ~ 6 Rogers~14.5-15)*
- *Wide bandwidth (higher coupling)*
- *Lower impedance capability (Power Amp Matching, e.g. GaN, SiC devices)*

DLI Thin Film Technology









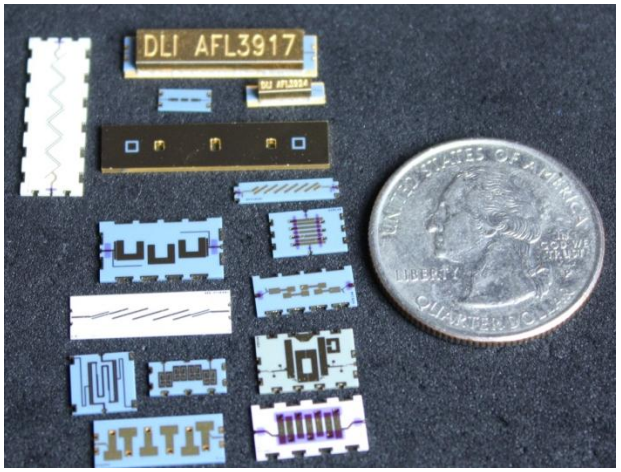
Custom Thin Film Processes

- *Dedicated, Experienced Product Team provides Rapid Design, Prototyping & Scale Up*
- *Experienced with virtually all thin film systems & processes*
- *Expert on Alumina [99.6 %] (Al_2O_3), Aluminum Nitride (AlN), Fused Quartz–Silica (Si02), Titanates ($Ti0_2$), Zirconia ($Zr0_2$) & DLI custom formulated Ceramics*
- *Metal deposition: RF sputtering, Electro-less & Electro-plating*
  - *TiW, Au,TaN, 80/20 AuSn, Pt, Ni, Sn (Ti, Chrome, Cu,)*
- *2 sided aligned patterning*
- *Photo Lithography: Wet, and Dry film (via processing)*
- *High Precision Saw Dicing*
- *State of the art Laser via drill*
- *Substrate Lapping & polishing*
- *Automated Dimensional Measurements*
- *Automated inspection and placement on tape*
- *Packaging: Waffle pack, Tape & Reel, Tape ring*
- *Partnerships with specialty contractors for Laser scribe & trim, via fill, thick /thin film Cu for high power applications and for high volume applications/backup*

‘*Disruptive Component Technologies’ for RF & Microwave Systems*

Miniature Microwave Thin Film Filters & Components

- Custom Designs/ Hi-K Ceramics
  - •300MHz ~67+GHz
  - •SMT
  - •Chip & Wire
- •New Oscillators products
- •New TF Circulator products
- •New Integrated MW Assemblies

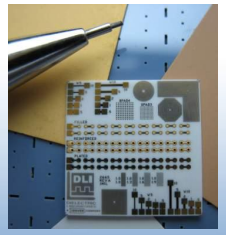


Hi-Q MLC’s

- •0402 ~3838 case sizes
- •RF Power
- •Broadband DC Blocks

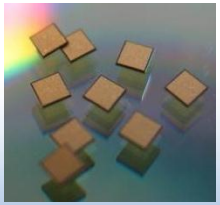
Thin Film - Build to Print Foundry & Fabrication Services

- *Wide range of standard & DLI proprietary Ceramics 4<K<40,000*
- *•Metallization: TiW, Pt, Ni, Cu, Au,*
- *TaN resistors*
- *•Features to 0.5 mils*
- *•Laser Vias / Filled Vias*
- *•Polyimide Multi-layer in R&D*
- *•RF testing service/ Screening option*



Single Layer Ceramic Capacitors

- •Widest selection of SLC’s
- • 4<K40,000
- •Temperature stable /Hi-Q matching
- •Decoupling/ DC blocking
- •Metallization , many options
- •Microwave Modeling CAPCAD™
- •Custom Solutions
- •QPL Listing expected late 2013



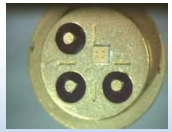
Heat Sinks, Stand-Offs, Laser Sub Mounts

For the fiber optics industry

- Customized Designs,
- High Volume
- Price Competitive

Laser, PIN Diodes, VCSEL’s mounts and standoff applications

Including the next generation of **‘smart’ heat-sinks**



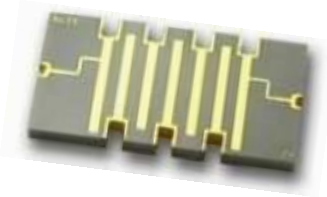
CERAMIC & MICROWAVE PRODUCTS

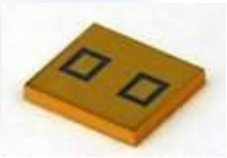
DLI DIELECTRIC LABORATORIES

BSC FILTERS • DIELECTRIC LABORATORIES • DOW-KEY MICROWAVE • K&L MICROWAVE • NOVACAP • POLE/ZERO • SYFER TECHNOLOGY • VOLTRONICS

Custom Thin Film

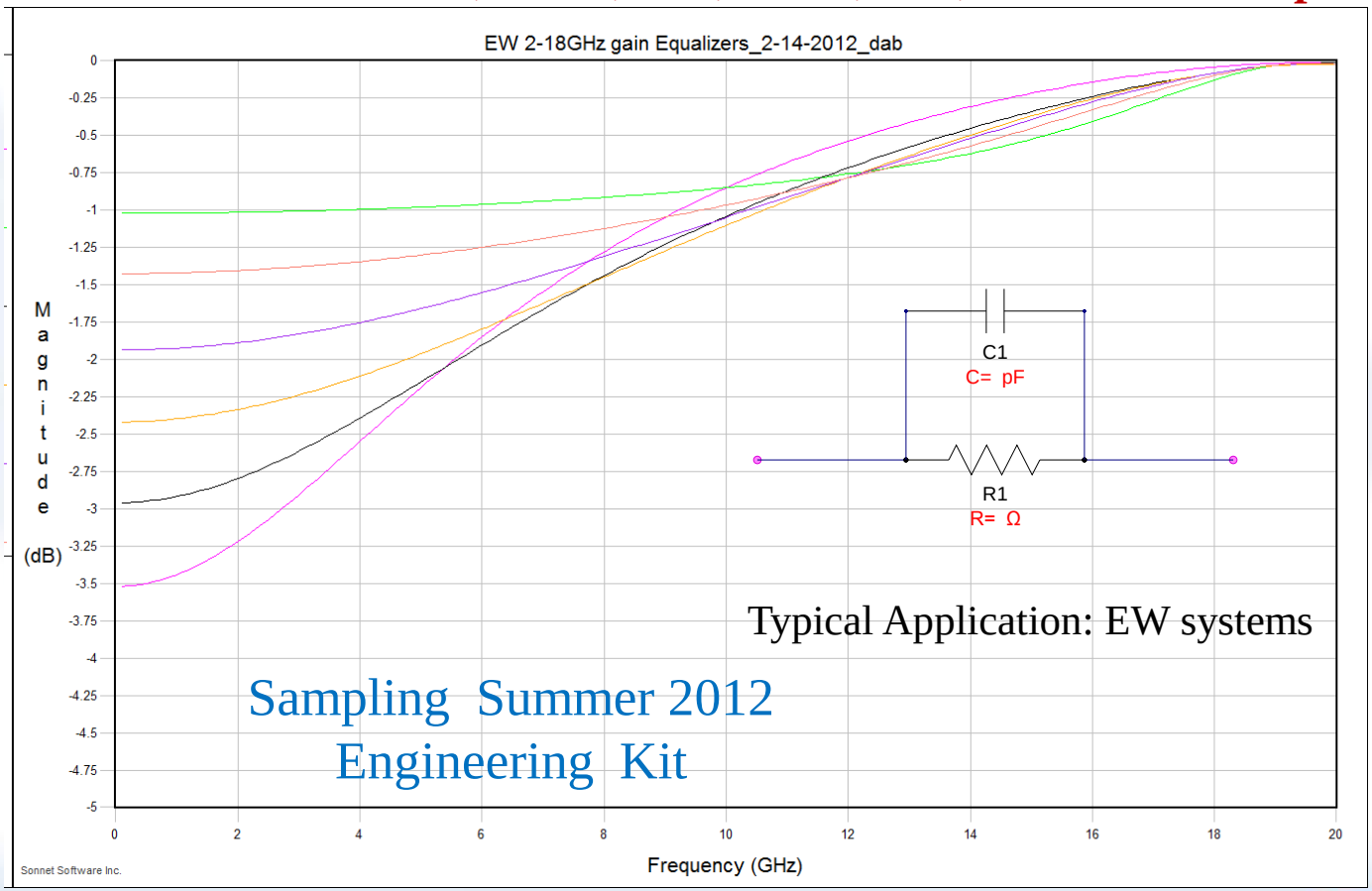
- *Ceramic Filters (BP/Reject, Low/High Pass, Notch, Diplexers, Duplexers, etc.)*
- *Resonators (Single Frequency (One and Two port)*
  - *Including full Oscillator reference designs*
- *Gain Equalizers, Bias Filter Networks,*
- *And other custom thin film ceramic components*
- *Providing Electronic Components and Microwave Solutions to you!*
  - *Filter Family - Micro-strip, cavity filters, Duplexers, Diplexers, GPS filters*
    - *Frequencies from <300MHz to >67GHz*
    - *Value-added, no tuning required*
    - *Extremely temperature stable from "outer space to the desert"*
    - *Miniature and lightweight*
    - *Typical characteristics*
      - *Low insertion loss*
        - *Steep skirts*
        - *High out-of band rejection*

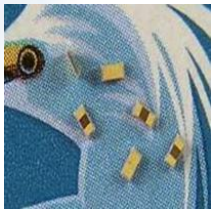




Gain Equalizer Series for DC~18GHz 1 to 3.5dB slopes, 0302 Case size

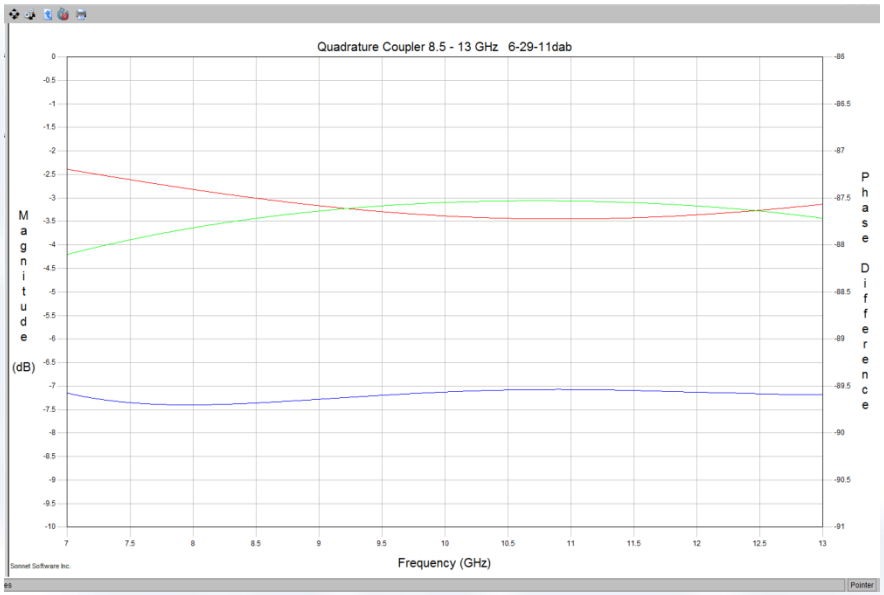
- *Expanded Series of Equalizers Collecting Requests for "Standard Parts"*
  - *Recurring requests for 2~18 GHz band (typical of EW applications)*
    - *Standard Values : 1dB, 1.5dB, 2dB, 2.5dB, 3dB, 3.5dB in Development*

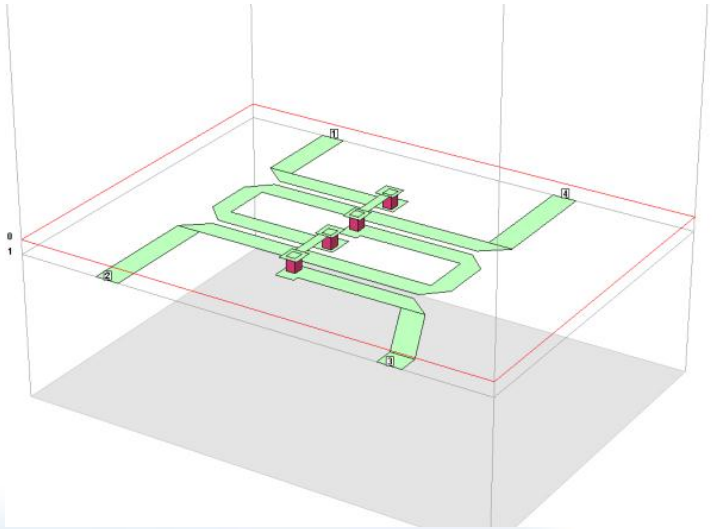




Quadrature Power Dividers

- *New Polyimide Multi-Layer process is enabling as an example a 9 GHz SMT Part*





- *Popular circuit elements such as "Lange Couplers (above) used in thin film MCM's for Mixers and Power Combiners.*
- *Balanced configuration has great VSWR benefits.*
- *High K ceramics can significantly miniaturize these devices.*
- *Possible opportunity to displace Alumina Thin Films or current suppliers in MCM's and high $ assemblies.*

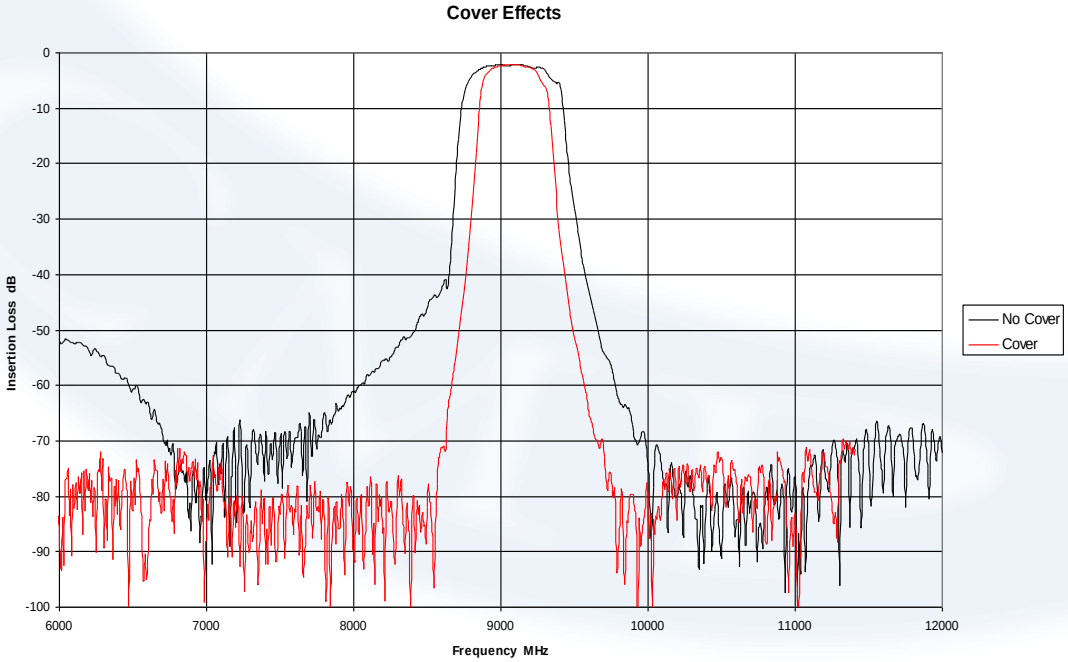
DLI Filters, Strengths

- *Small size (footprint & height)*
  - *Cover heights as low as 0.050 inches,*
  - *virtually all parts < 0.11 inches w/ shield cover*
  - *Typical area <0.1 in^2*
  - *volume (typical <0.01 in^3), weight (typical <0.3grams)*
- *All filter types Low pass, High Pass, Band Pass, Notch, Cavity, Diplexer, Duplexers and Triplexer*
- *Temperature stable (~3ppm/°C)*
- *Excellent RF repeatability*
- *Excellent design model and first pass design success.*
- *Low cost, no tune, Batch processed*
- *Repeatable SMT performance to 60GHz + (patent pending)*
- *RF probe test, vector S-parameters de-embedded to contacts.*

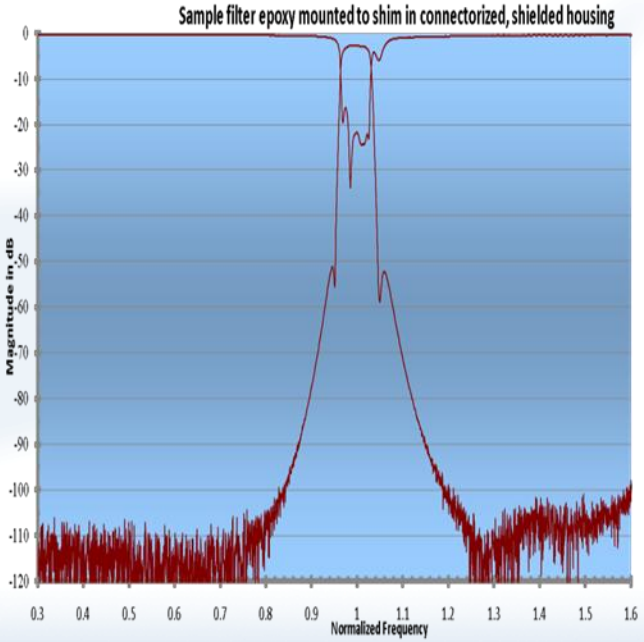
Filter

High K substrate provides Higher Field confinement

9 GHz Filter (30 mil CF with and without cover)
removing shield cover has relatively small effect

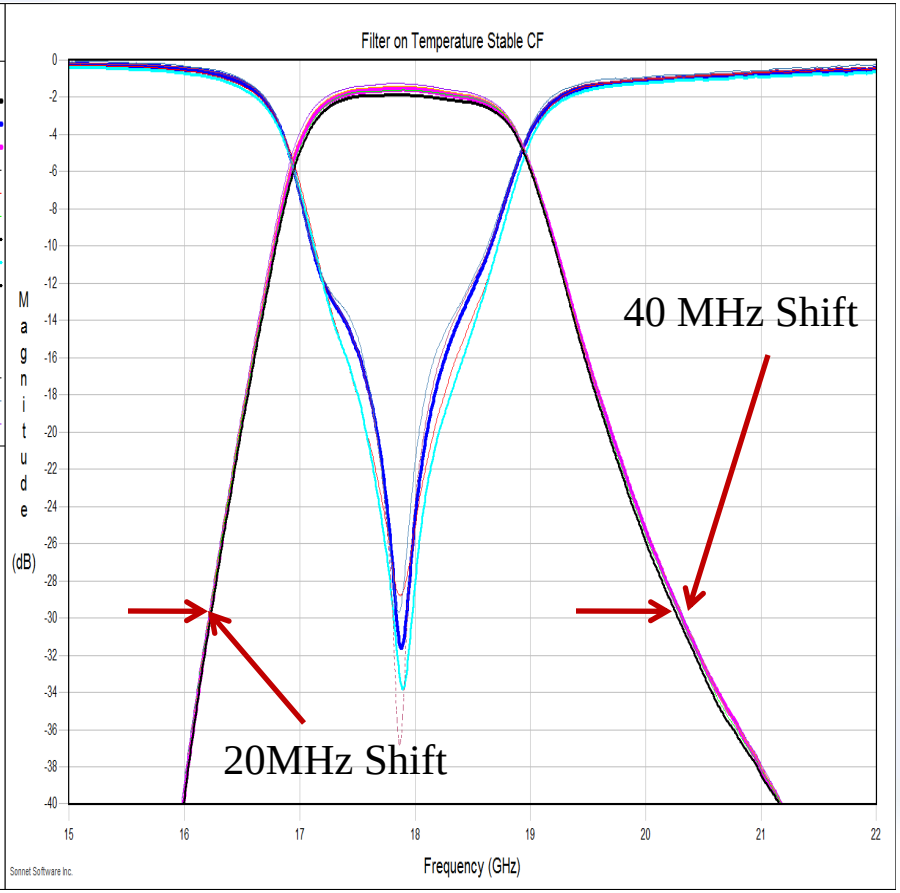


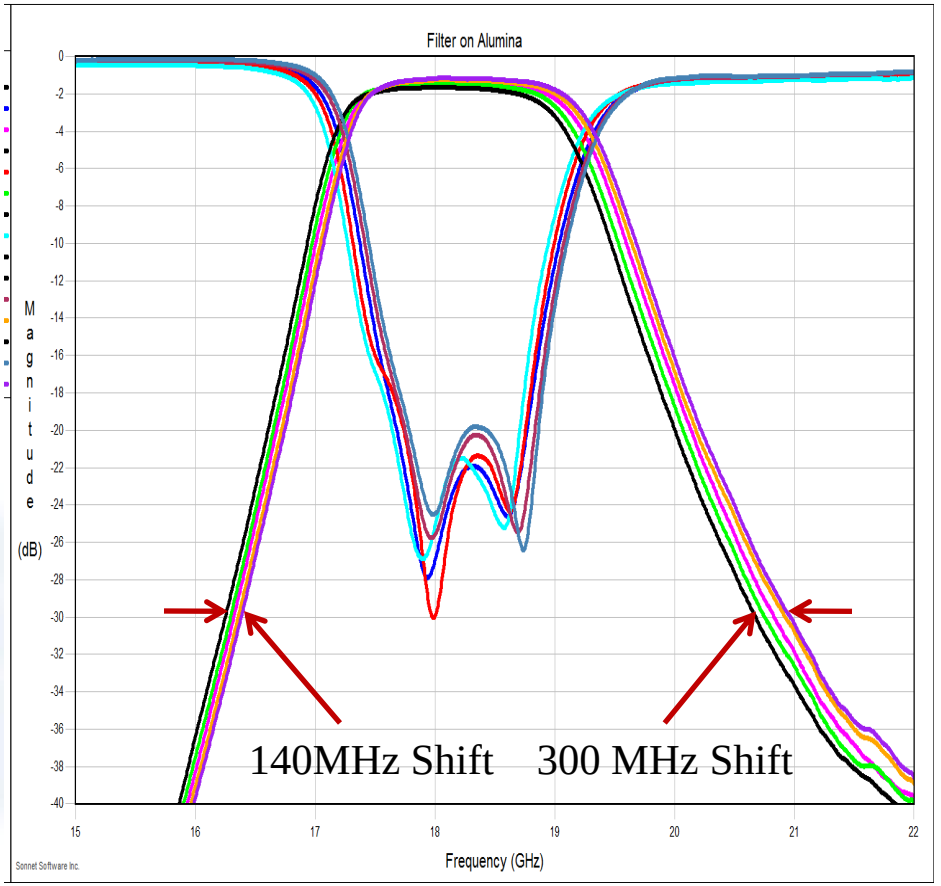
Outstanding rejection possible



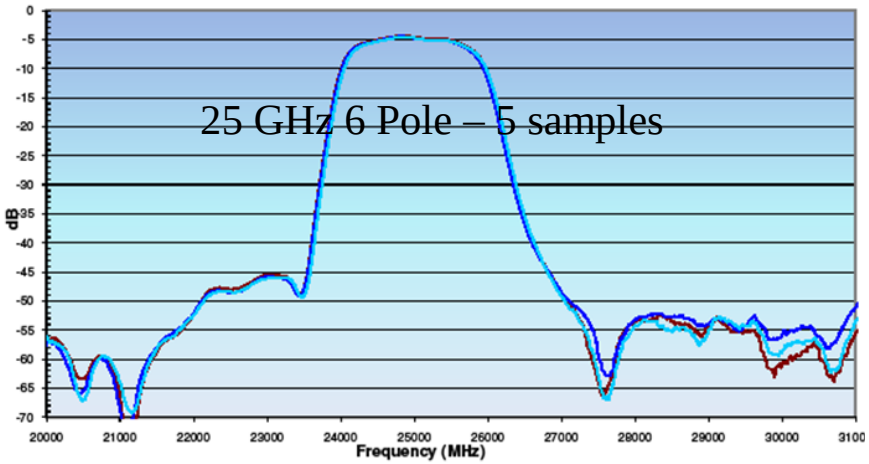
Filter Temperature Stability (-55 to +125 °C)
"CF" versus Alumina (18 GHz Band-pass Filters)

Most Systems Specify -40 to +85°C



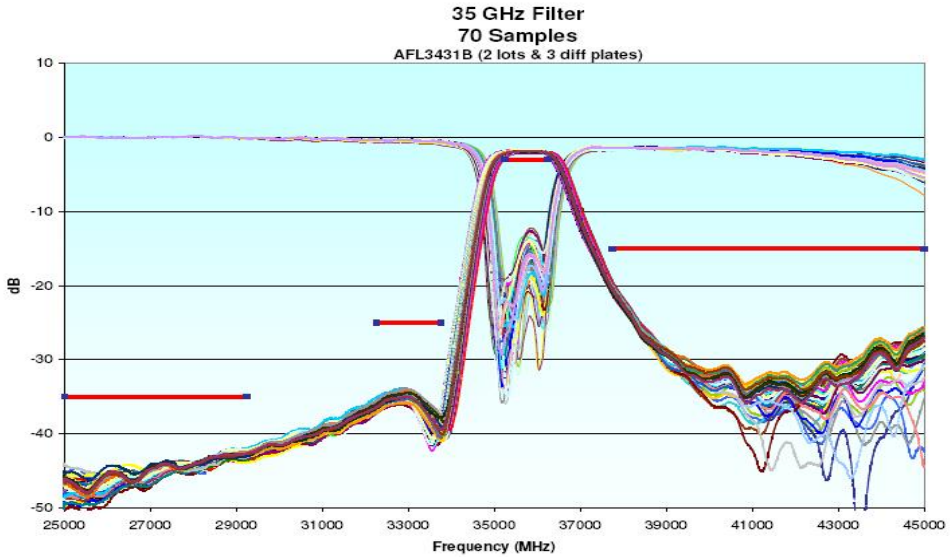


Examples of Filter Repeatability

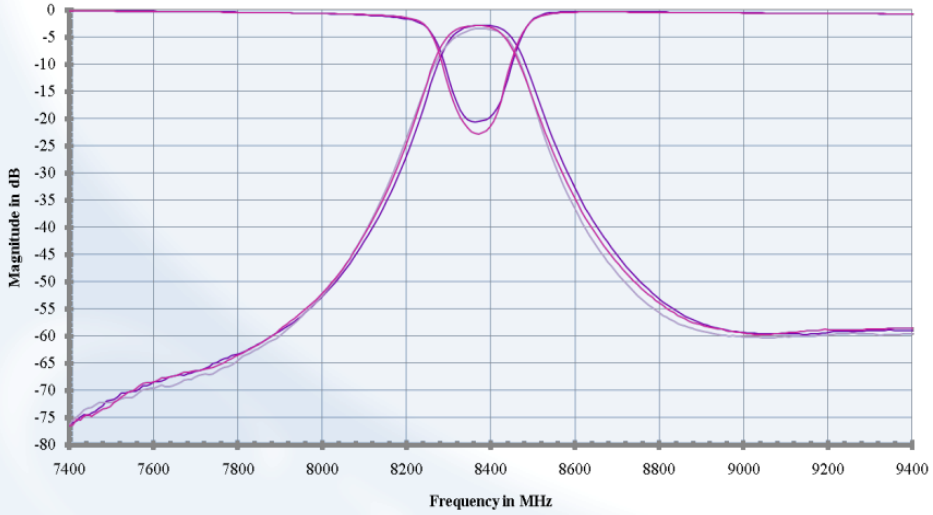


0.25 x0.10 inches

70 Samples
2 different plates,
3 different lots of materials



Cavity Filter Examples



10.5 GHz 4 Pole CF Cavity Filter

<3.5db mid-band loss
.75 x.18 x.03 inches
Data scalable thru Ku band

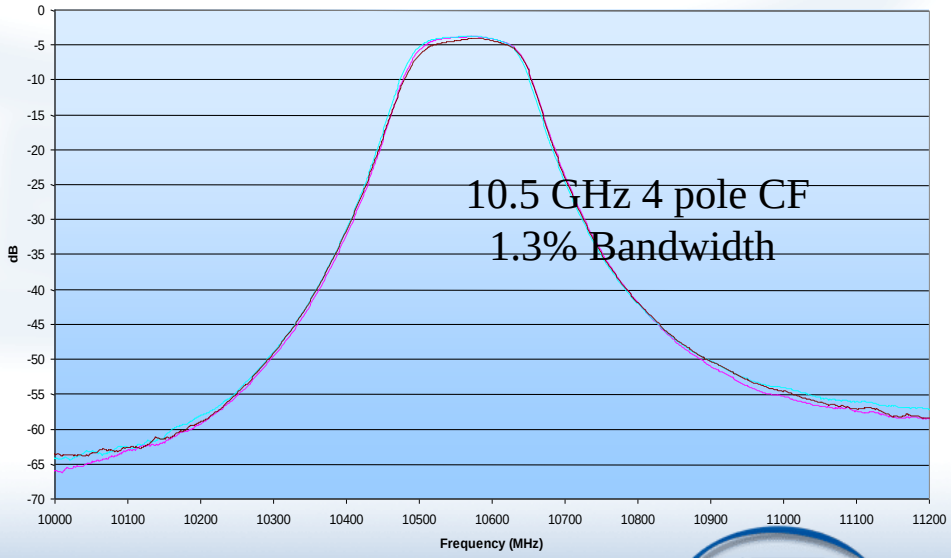
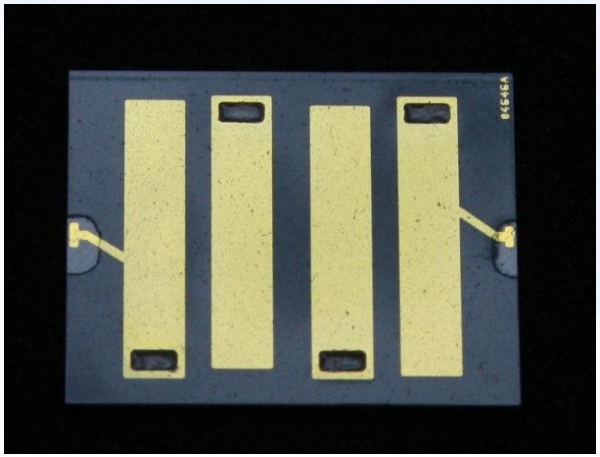
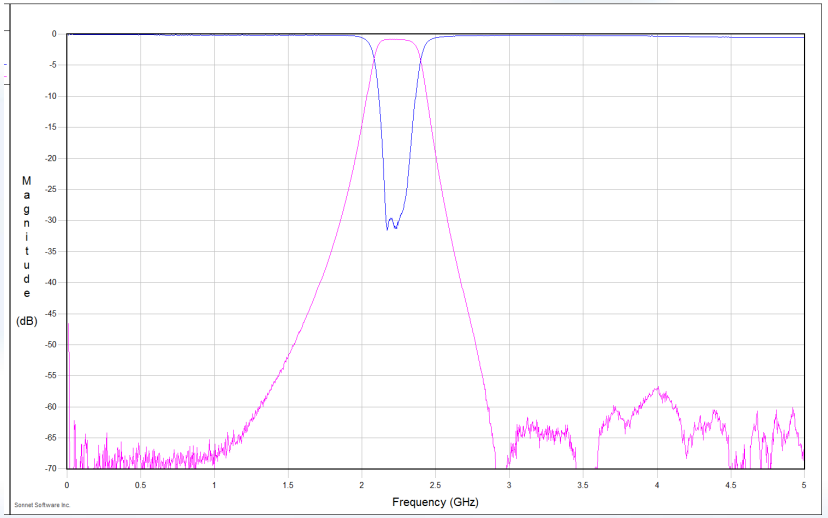


Photo Defined Polyimide cover-layer

- ***Protection from: RF Voltage Breakdown, High power, condensation and altitude effects @ power***
- ***Moisture Condensation on surface of filter causes Frequency de-tuning and Increased insertion loss***
- ***Opportunities to penetrate higher power & space applications***



2.2 GHz High Power Filter50 Watt CW

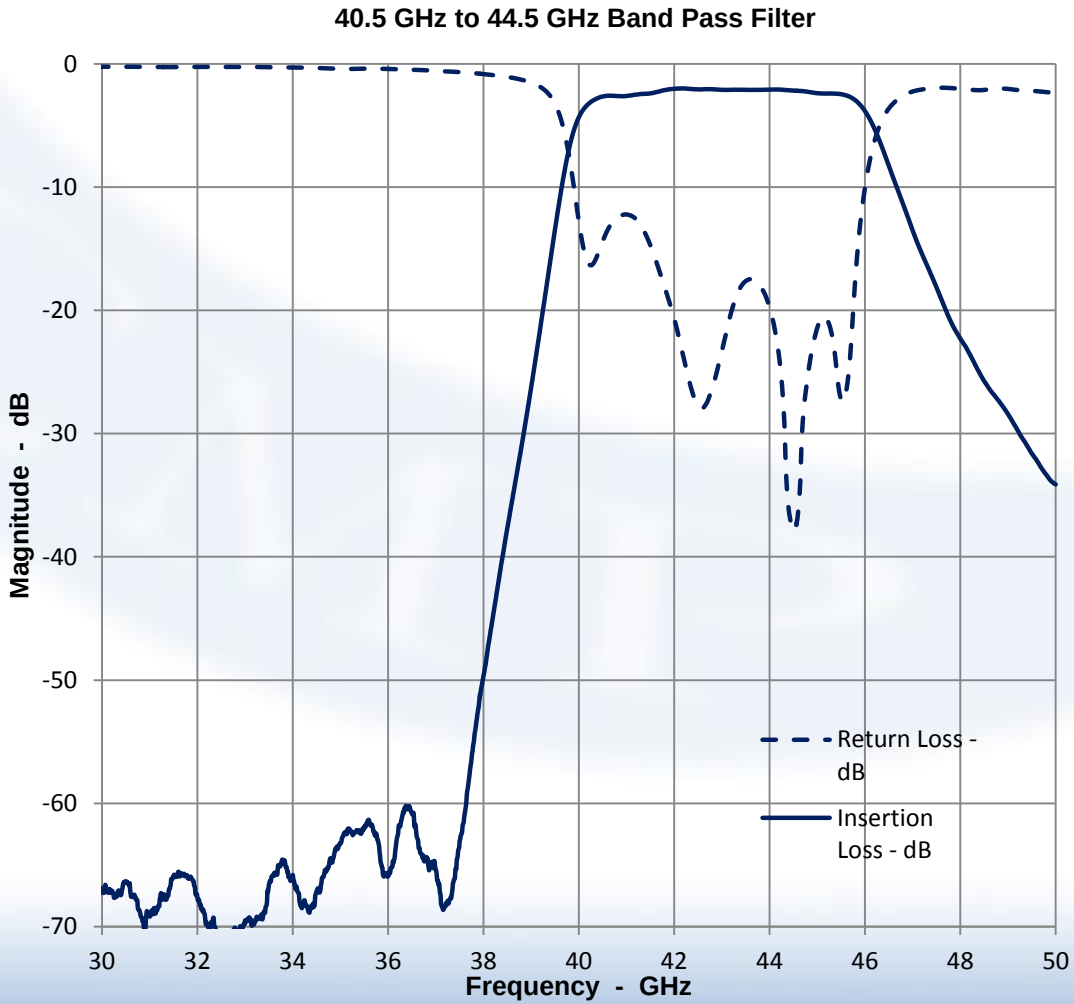


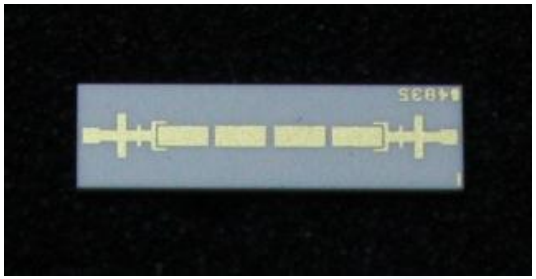
New Product Directions

- *30~ 60+ GHz Range SMT Filters*
- *SMT Filters with Copper Thin Film Metallization - Lower Cost & Lower Loss*
- *Multi-layer printed lumped element filters*
  - *Smaller low frequency filters, low pass, high pass, band-pass, wider fractional bandwidths, broad high side stop-band*
  - *Quasi-suspended substrate filters & SMT*
  - *Defected ground filters & SMT*
- *Cavity filters, reduced loss & higher selectivity (narrowband filters ~ > 6 GHz)*
  - *Multi-Layer Cavity Filter, for Reduced Footprint*
    - *Cross coupled , higher selectivity with low loss*
  - *Thicker lower K materials (lower loss, frequencies to ~30 GHz feasible)*
- *Oscillator Reference Designs*
- *TF Circulators*
- *Integrated Microwave Assemblies*
- *Agile devices (from the acquisition of Agile RF)*

SMT 40~43 GHz Filter Point-to-Point Radio

Demonstrated Excellent Performance in Surface Mount Form
Customers requesting integral shield –technical challenge

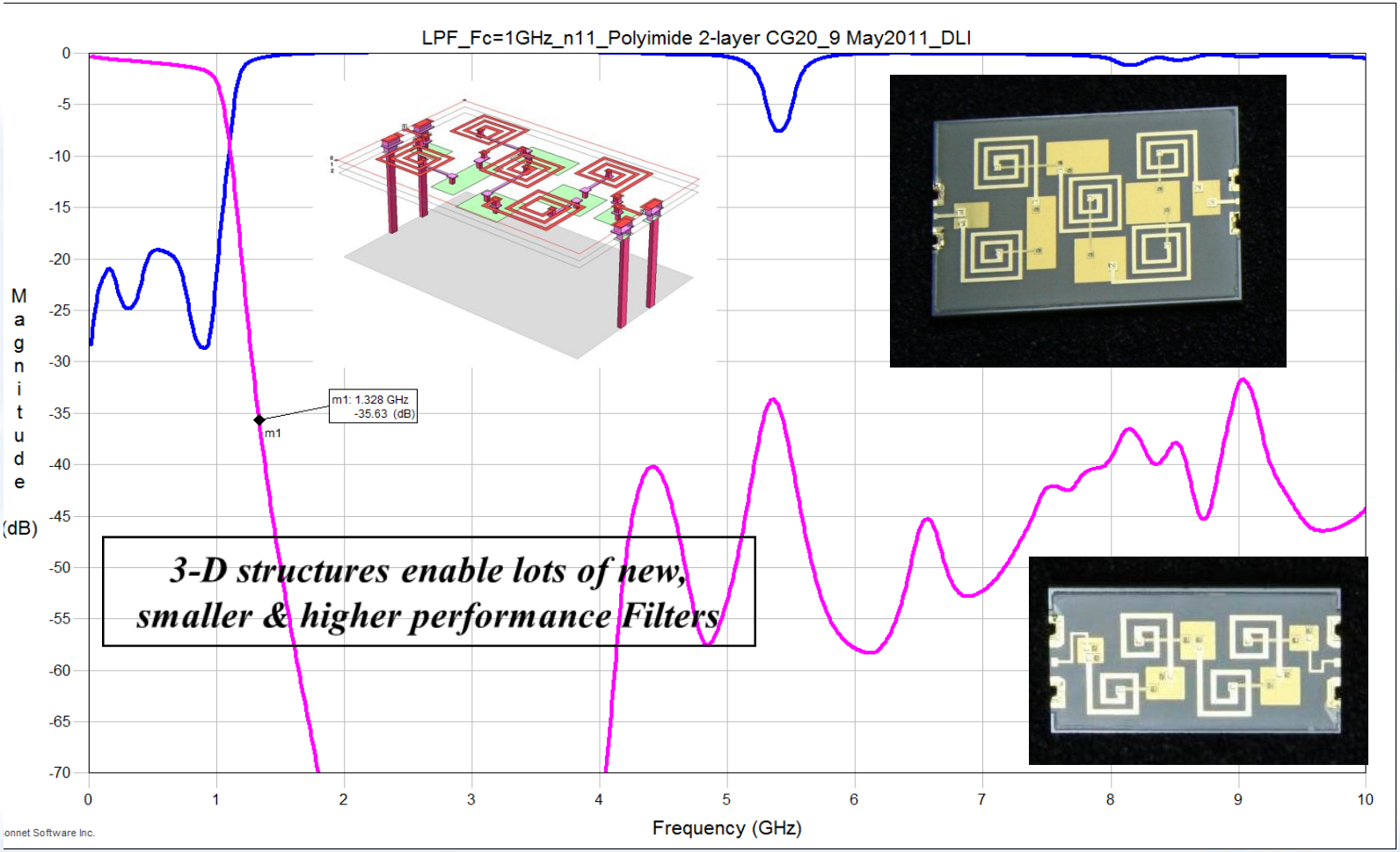




4 Pole Filter
Size: 275 x 80 x 10 mils

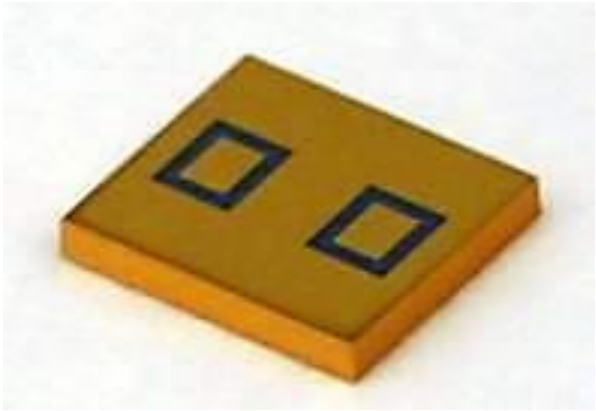
Advanced Miniature Thin Film Filter Technologies
Multi-layer polyimide & K67 thin film Lumped element 1 GHz LPF

Multi-Layer Thin film on Hi-K Ceramic
Miniature 1GHz LP Filters (0.44x0.30x0.025

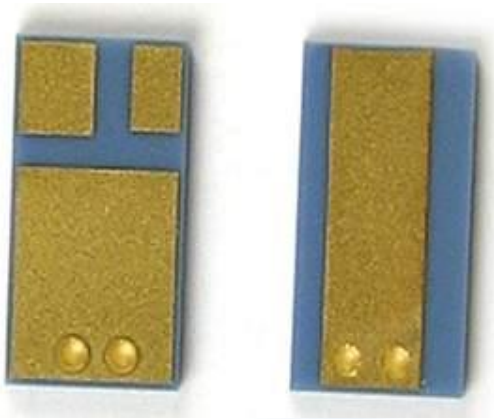


DLI Ceramic Cavity Resonators

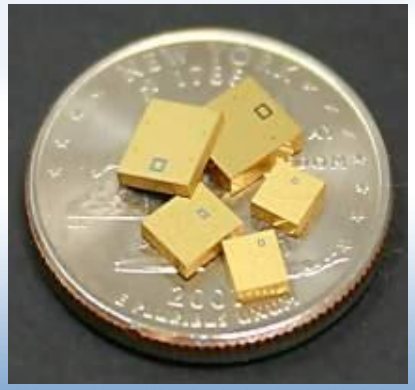
One Port Cavity Resonator
- *"Single Frequency"*
- *Integrated coupling capacitor*
- *From 3~67 GHz*



Two Port Cavity Resonator
- *Tuning up to 3%*
- *Integrated coupling capacitors*
- *From 3 ~ 30 GHz*



Microstrip Tunable Resonator
- *Tuning up to 10 %*
- *Integrated coupling capacitor*
- *SMT mounting*
- *From 1~12 GHz*



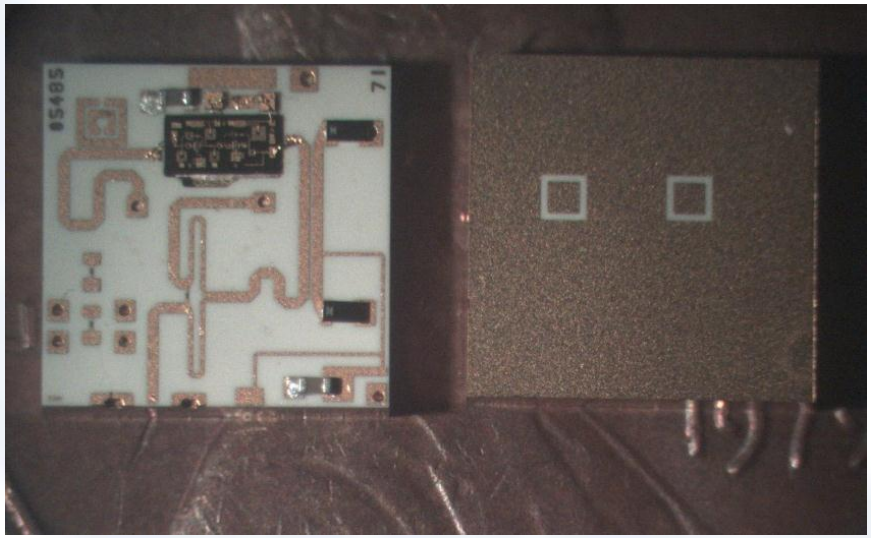
DLI Ceramic Cavity Resonators

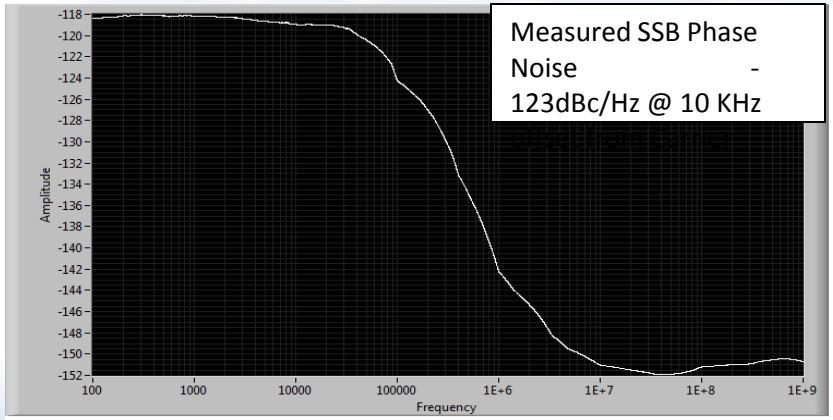
- *DLI's 'Disruptive Technology' is patented with a World Wide PCT filing*
- *Some of the advantages of this resonator technology are:*
  - *Hi-Q, (up to 2000), low loss, enables very low phase noise oscillators*
  - *Coupling capacitors are integrated and tailored to the desired tuning range of the oscillator – inside of the package*
  - *Capable of much higher frequencies than alternative technologies*
  - *Fully shielded – no large expensive housings or tuning screws*
  - *Frequency stability to <3ppm/°C*
  - *Ready for automated assembly*
  - *Reference designs for oscillator products*

- *In addition to all of the other benefits depicted in an earlier slide they*
  - *Are tested to be Rad Hardened to > 1 Mega-Rad with no performance degradation*
  - *Do not exhibit aging characteristics*
  - *The Q leverage improves with increasing frequencies*
  - *Do not out-gas due to density of the material*

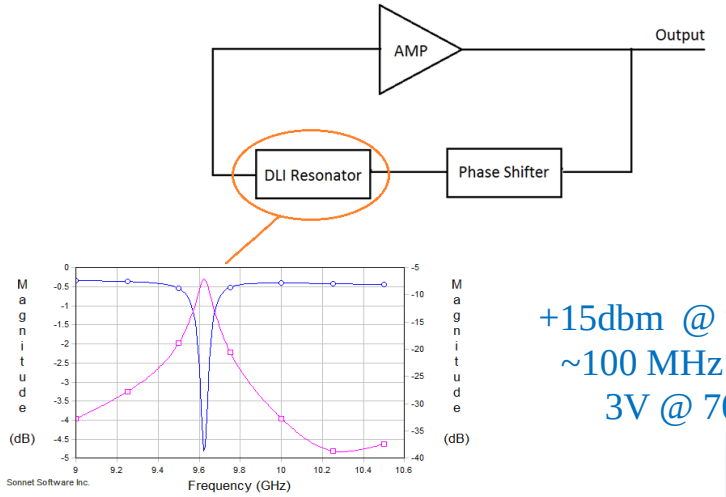
Low Phase Noise Oscillators >6 GHz DLI Ceramic Cavity Resonator Stabilized, Q_u to 1000

oscillator assembly integrated to the top of the DLI resonator sitting on a penny:

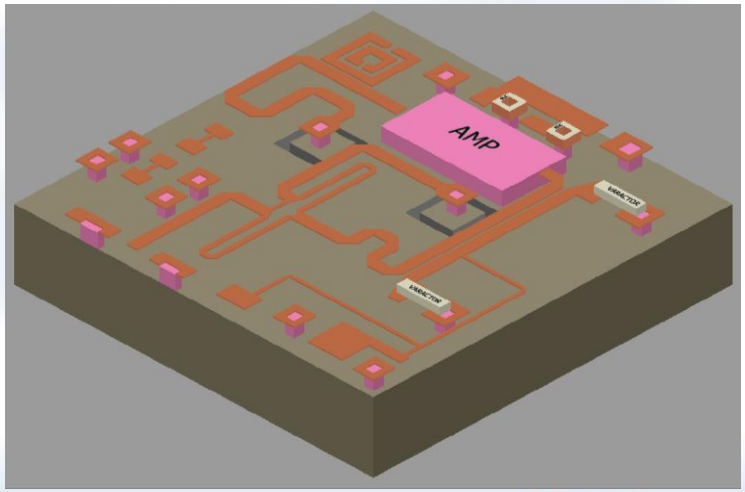




Measured SSB Phase Noise - 123dBc/Hz @ 10 KHz



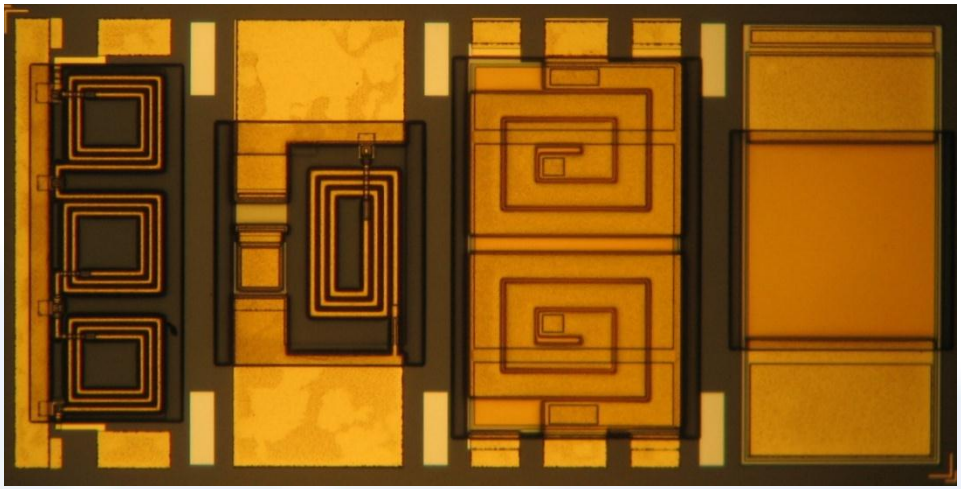
+15dbm @ 9.9 GHz
~100 MHz tuning
3V @ 70ma



BST Technology

- *Voltage Tunable Low Pass Filter – Expected to tune over roughly 5-10GHz*
  - *~ 40x15mil*
  - *There are 4 caps = ~ .5x.5 mil*
- *Voltage Tunable Gain Equalizer*
  - *4 dielectric layers*
  - *3 metals layers*
  - *Silicon nitride caps,*
  - *BST caps*
  - *Thin film Resistor*
  - *~15x 40 mils*

- *High Current Bias Filter Network*

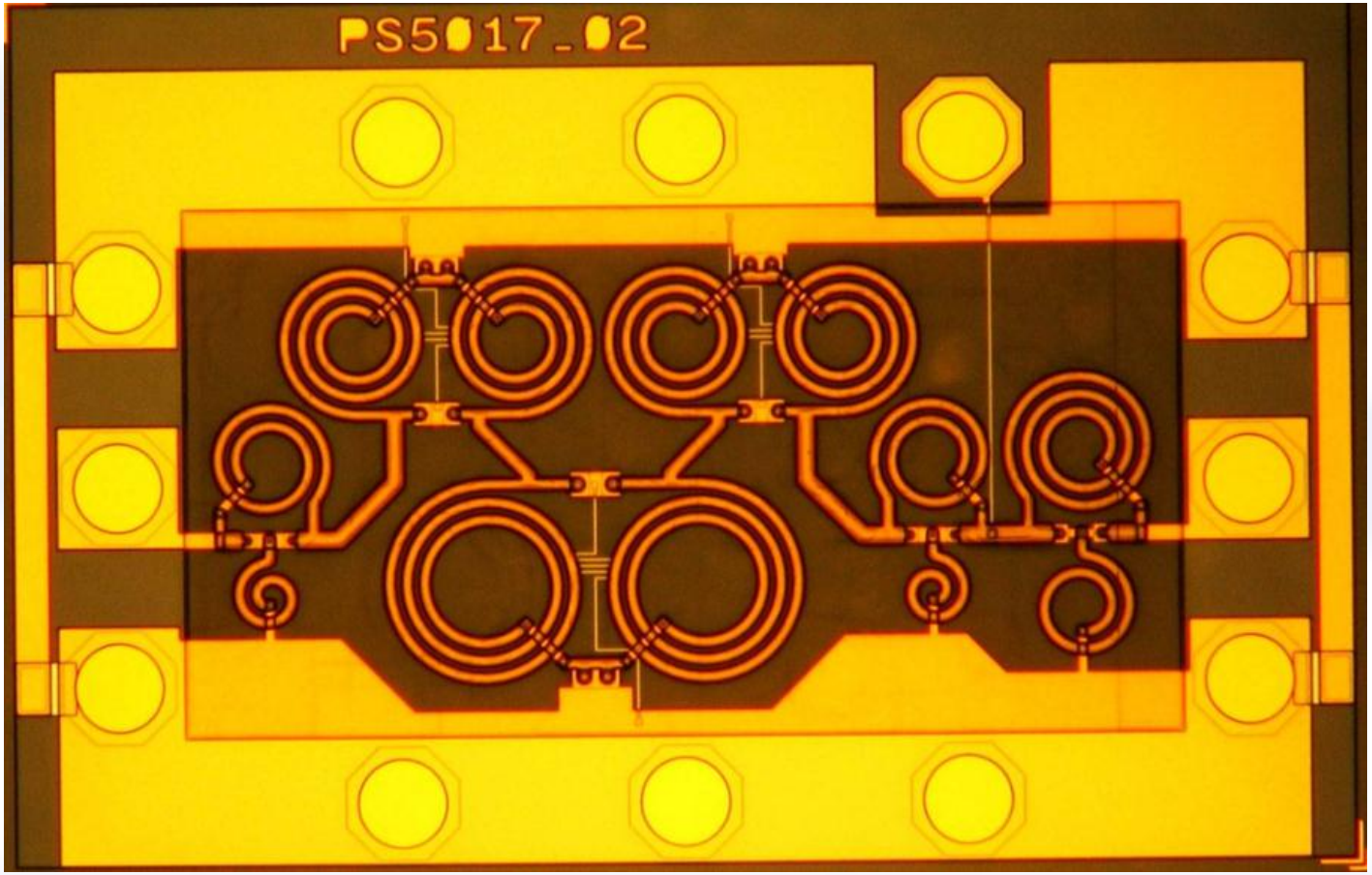


*There are **4 Circuits** in this picture*

All are currently on 8mil thick sapphire
Circuits are ~ quarter of a mil thick.

- *Surface Mount Cap (similar to DLI Gap Gap)*
  - *Over 5000pF*
  - *Designed to replace our OptiCap from 1MHz to more than 40GHz.*

BST on Sapphire Analog Phase Shifter



Questions?

Thank you !

Have a great day ☺