

3D Printed RF Structures Open the Potential to Think Out of the Box

Presented by:

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Agenda

- Simple overview of Radix™ 3D-Printable RF material
- Review of Radix material being used to create GRIN structures with 3D printing
- New evaluations using Radix material, with different 3D printed RF structures



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Rogers Radix™ 3D-printable dielectric materials provide a scalable solution to manufacturing gradient index and complex dielectric parts that enable our customers to enhance the figure-of-merits of their RF systems

Rogers Radix Printable Dielectrics



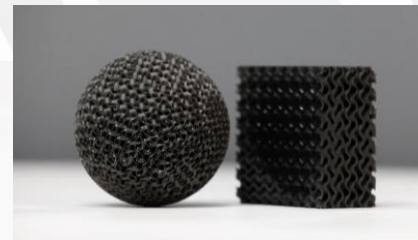
Rogers new low-loss uv-curable resin

used on DLP printing systems



Fortify DLP 3D Printer

to create new RF dielectric components



Gradient index (GRIN) lenses and 3D circuits

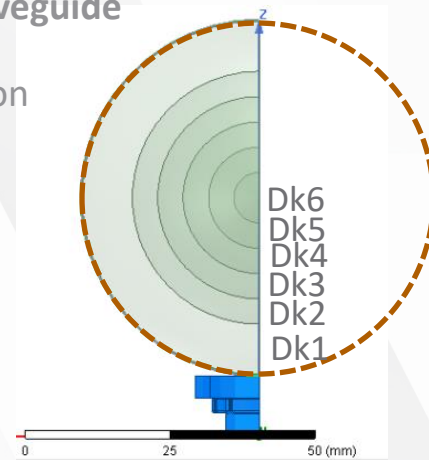
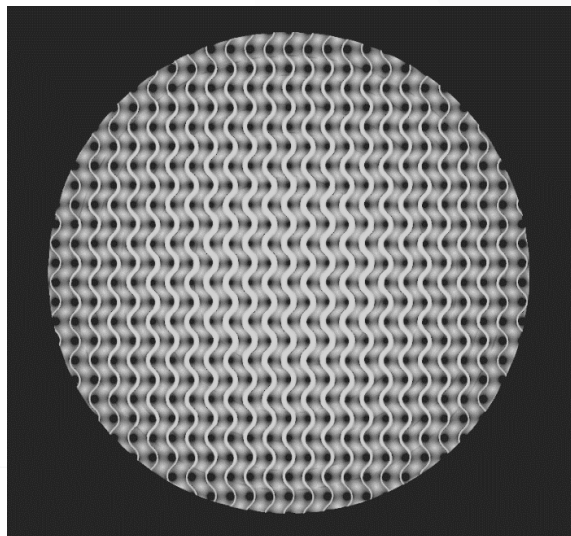
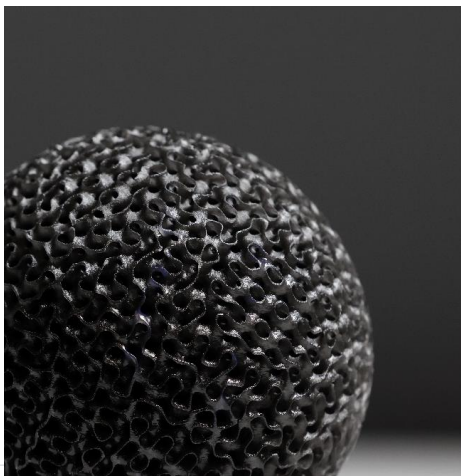
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Spherical, 1-2 Dk Lens Design

Conventional (1-2 Dk) Luneburg lenses tested at 27-30 GHz, fed with WR-34 waveguide

- Used standard DLP material with a loss tangent of 0.039 @ 10 GHz
- Used Radix™ material with a loss tangent of 0.0044 @ 10 GHz for a comparison
- Tested at a first position and then rotated 90° for a second position

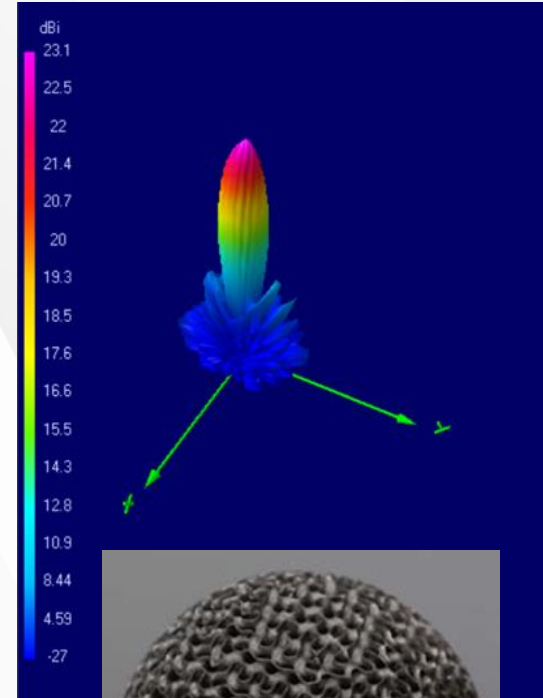
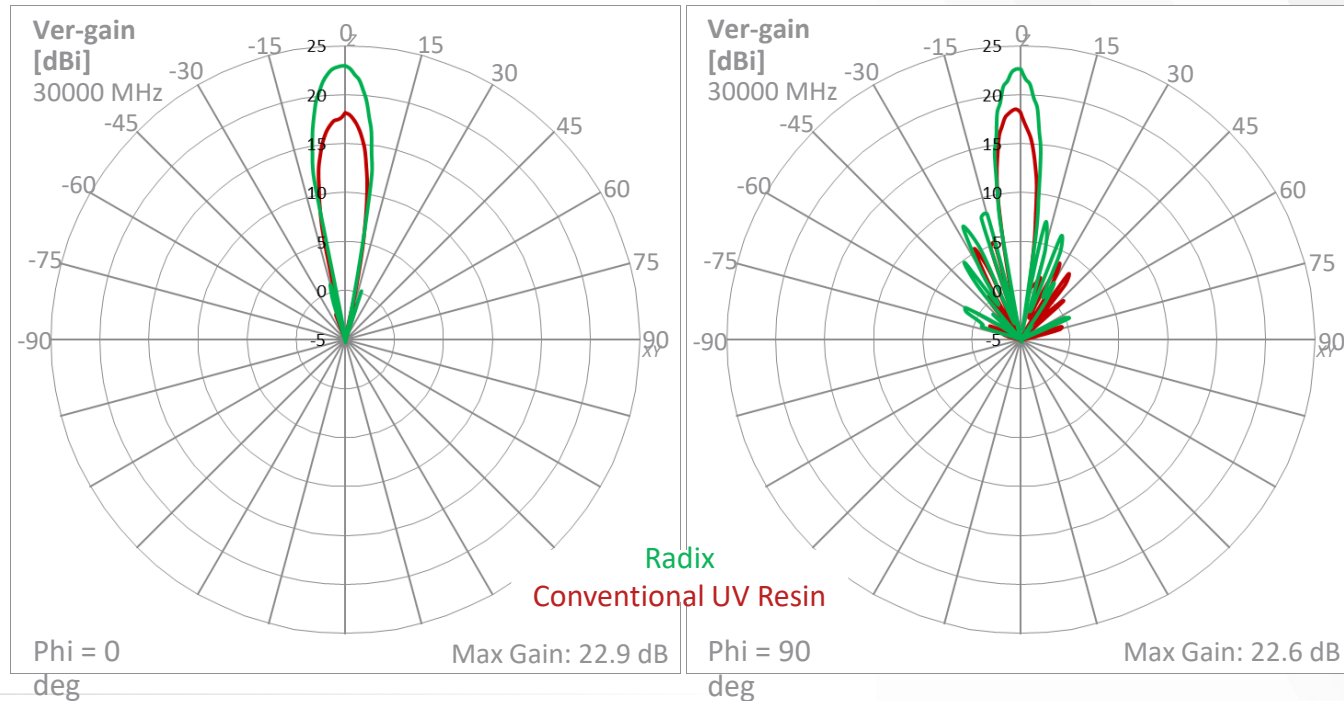
Results match simulation and are consistent in all positions, with Rogers' material providing >3dB better gain performance



Dk1 = 1.11	@ R = 31.0mm
Dk2 = 1.26	@ R = 27.9mm
Dk3 = 1.42	@ R = 25.4mm
Dk4 = 1.59	@ R = 21.7mm
Dk5 = 1.75	@ R = 18.0mm
Dk6 = 1.92	@ R = 12.4mm

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Measured results using 3D printed Radix™ material for a Luneburg lens



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- The Radix™ 3D-printable RF material can be used to create a huge variety of RF structures
- For a relatively simple experiment we have investigated different, basic radome designs
- The experimental radome designs are shown here
- There are four different radome designs and each are using the 3D-printable Radix material
 - The current Radix product has a Dk of 2.8
 - An experimental Radix product, that is early in the development stages, has a Dk of 4.6



Radome # 1, Dk = 2.8

Cross-sectional view



Radome # 2, Dk = 4.6
(experimental)

Cross-sectional view



Radome # 3, Dk = 2.8

Radome # 4, Dk = 4.6
(experimental)

Cross-sectional view



Radome # 5, Dk = 2.8

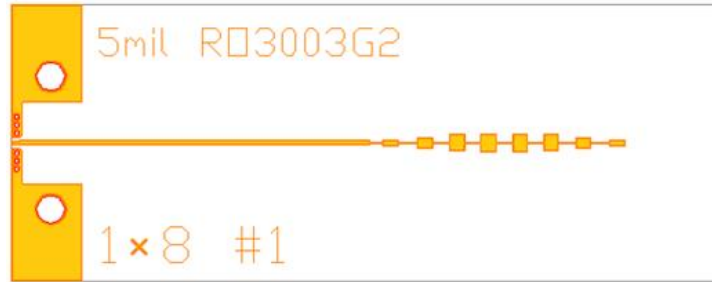
Radome # 6, Dk = 4.6
(experimental)

Cross-sectional view

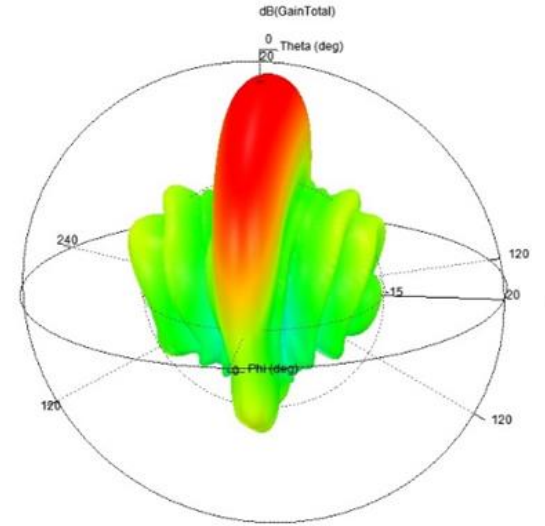
Radome/Lens # 7, Dk = 2.8

Radome/Lens # 8, Dk = 4.6
(experimental)

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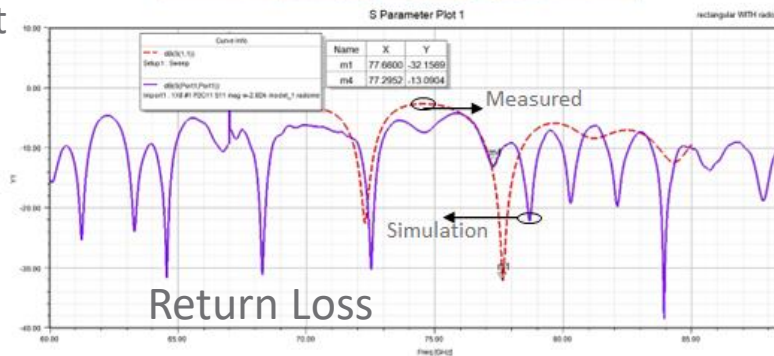
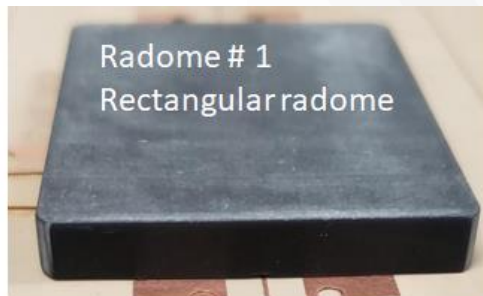
Top view of circuit



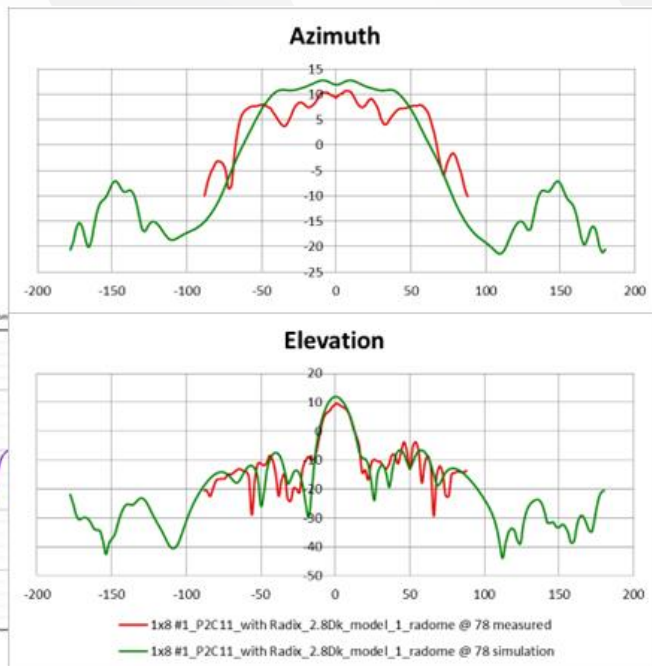
- Shown here is our mmWave antenna test vehicle to be used with our radome experiments
- The circuit is a microstrip series fed patch antenna built on 5mil RO3003G2™ laminate
- It is designed to operate at 76.9 GHz with 1.5 GHz bandwidth
- Modeled with Taylor distribution amplitude for low side lobe response

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- There is a good match between the measured results and the simulations
- There is room for improvement
- However, this was our first attempt and the design has not been optimized yet

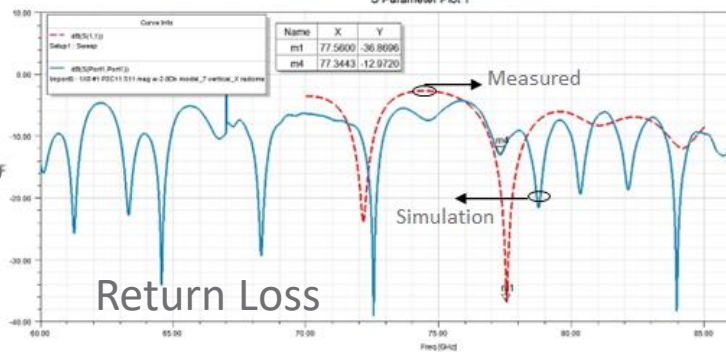
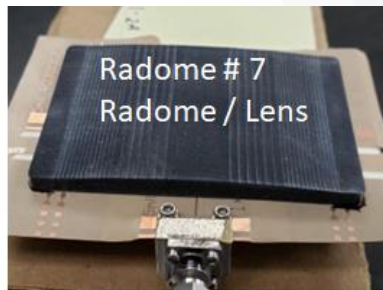


- Red curve is measured data
- Green curve is simulation
- Connector losses are included in the measured data

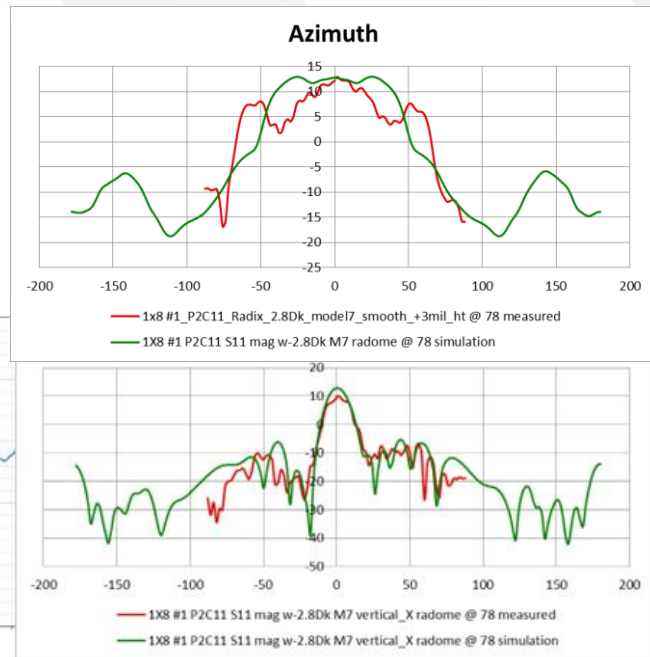


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- There is a good match between the measured results and the simulations
- This design is a radome with a lens effect
- The lens effect is intended to collimate the radiation pattern
- This is our first attempt and there are multiple things that can be done to optimize this design



- Red curve is measured data
- Green curve is simulation
- Connector losses are included in the measured data





Thermal Stability Consistency is Even More Important at Millimeter-Wave Frequencies

Summary

- Radix™ material is a low loss RF material, that is used with 3D printing technology to create RF structures
- We have demonstrated that the Radix material can be used to create RF structures using GRIN technology
- We have also shared some of our results from a few experiments with Radix material, showing measured results and compared to simulations
 - Admittedly, these structures would need to be optimized for more demanding applications
 - However, our experiments show feasibility and RF models can correlate well to this technology
- There are many RF structures that can be made with the low loss 3D printable Radix materials and we have demonstrated only a few

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