Permittivity measurements on a variety of light weight refractory materials manufactured by ZIRCAR Ceramics, Inc.

Ceramics Expo 2019

History

- ZIRCAR Ceramics, Inc. 100 N. Main Street, Florida, New York 10921 USA
- 60 miles North West of New York City
- Incorporated June 2000 – 18 years old.
- Formerly Vacuum Formed Fiber Products Profit Center of **ZIRCAR Products, Inc**.
- ZPI – Originally Founded 1974 by **Bernie Hamling - Founder**

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ZIRCAR Ceramics, Inc.

- David P. Hamling -V/P
- Phil D. Hamling - President

Third Generation Hamlings

Joined ZCI Sept. 2011

- Phil Hamling - Sales
- Cole Hamling - Production

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Admin. & Engineering

- 100 N. Main Street

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“BMR” Plant and Warehouse

- 203 Black Meadow Rd.

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Assets – People

as of May 2018

- **46 Full Time Employees**
  - 5 degreed Engineers

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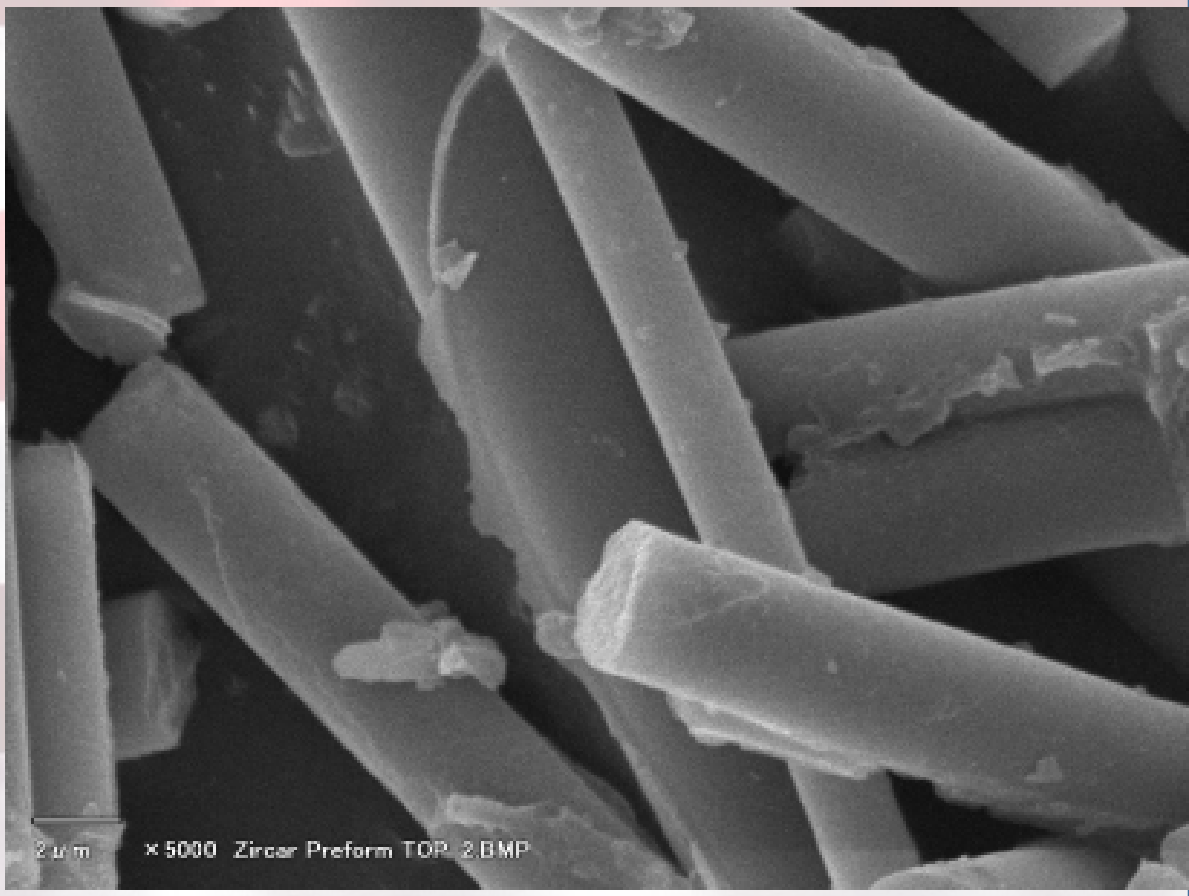
What Does ZCI Do?

- **Manufacture and Market Internationally**
- A wide range of high temperature ceramic fiber based thermal & electrical insulation products.
- Many other related products.



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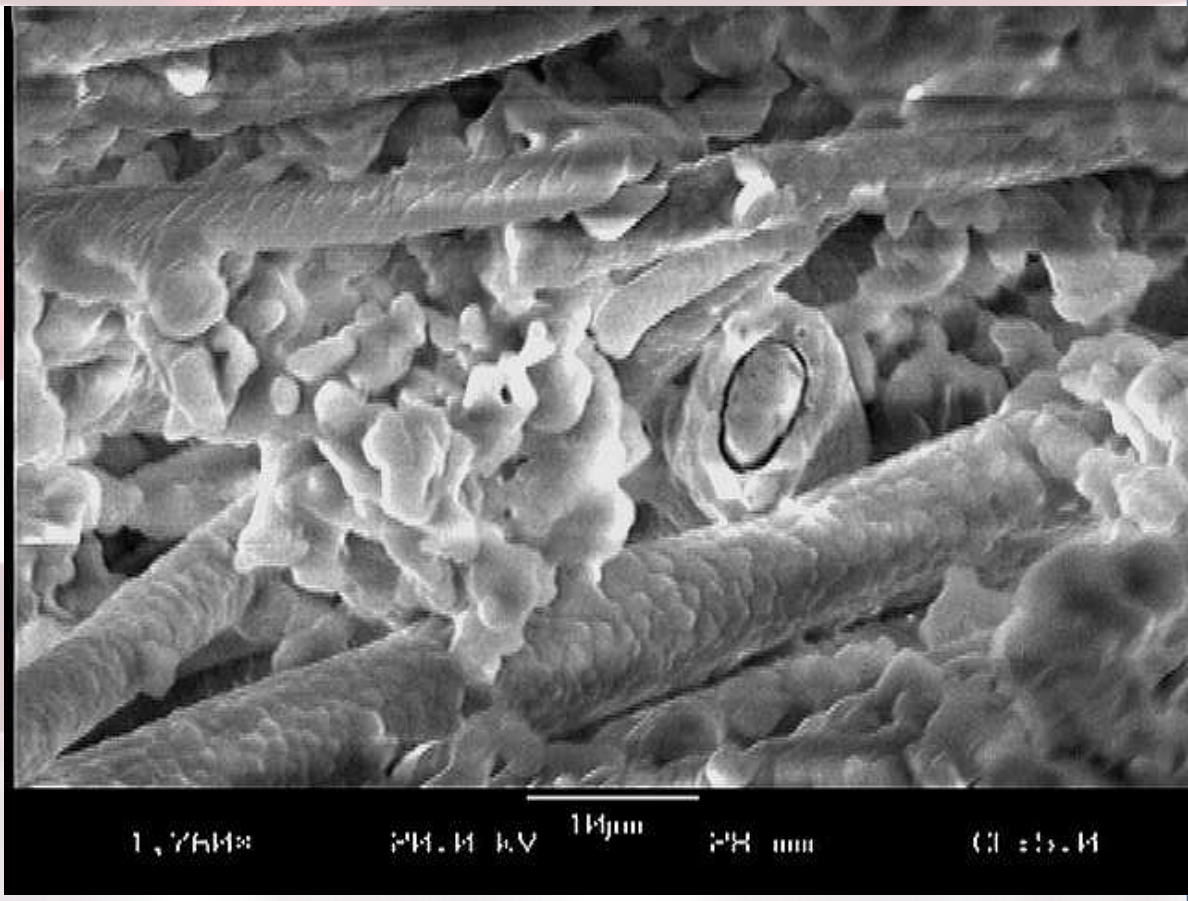
Heritage of High Performance

- **High Temperature Stability** and **Reliable Refractoriness** are possible only with **Properly Engineered & Combined** raw materials.
- This is our specialty!
- 40+ year history!



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What We Are Doing

- This paper presents Microwave Permittivity exhibited by a range of ZIRCAR Ceramics' low mass Al2O3 insulation materials.
- The data was collected in frequencies between 4GHz and 17GHz
- Testing was done at room temperature – 23C

What Are Microwave Frequencies

"**Microwaves** are a form of electromagnetic radiation with wavelengths ranging from about one meter to one millimeter; with **frequencies** between 300 MHz (1 m) and 300 GHz (1 mm). Different sources define different **frequency** ranges as **microwaves**; the above broad definition includes both UHF and EHF (millimeter wave) bands."

- Wikipedia, "Microwave"

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ε’ vs. ε’’

“Epsilon single-prime is the number we usually deal with, and causes no loss, and in most day-to-day engineering you don't see the prime notation. The imaginary *epsilon double-prime* is the culprit.”

- Microwaves 101, “Permittivity”

How

- A Transmission Tunnel with a transmitting antenna and a receiving antenna is set us as shown in the sketch.
- A flat panel test sample is inserted into the signal path of the Transmission Tunnel.
- A VNA (Vector Network Analyzer) is used to measure the Transmission (S21) through the test sample.
- Theoretical calculation of Transmission through a panel of identical thickness is computed.
- A search algorithm is employed to find the permittivity which results in the best fit of the computed transmission data to the measured transmission data.

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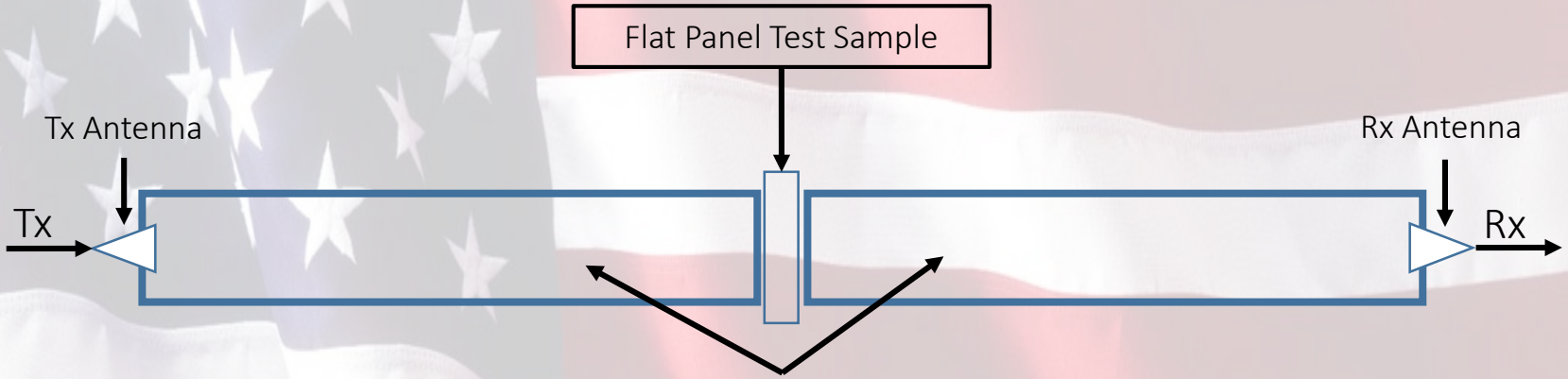
Transmission Tunnel Test Set-Up



Absorber Lined Transmission Tunnel

- 8in x 8in Cross Section
- 8 ft. total length, (4 ft. long each half)

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Materials Tested

Name	Type	Al2O3/SiO2	Density, pcf
ZAL-12	SiO2 bonded PCW	85/15	12
ZAL-12	SiO2 bonded PCW with AL-CEM coating	85/15*	12
ZAL-15	SiO2 bonded PCW	85/15	15
AL-25/1700	Al203-SiO2 bonded PCW & Al2O3 Powder	80/20	25
SALI	Mullite bonded PCW	80/20	30
AL-30AAHB	Al2O3 bonded PCW	98.4/1.6	32
ZAL-45AA	Al2O3 bonded PCW	97/3	45
Bubble Alumina	Al2O3 bonded hollow Al2O3 spheres	99+	60

* Applies to base ZAL-12 only, AL-Cem is 99+% Al2O3

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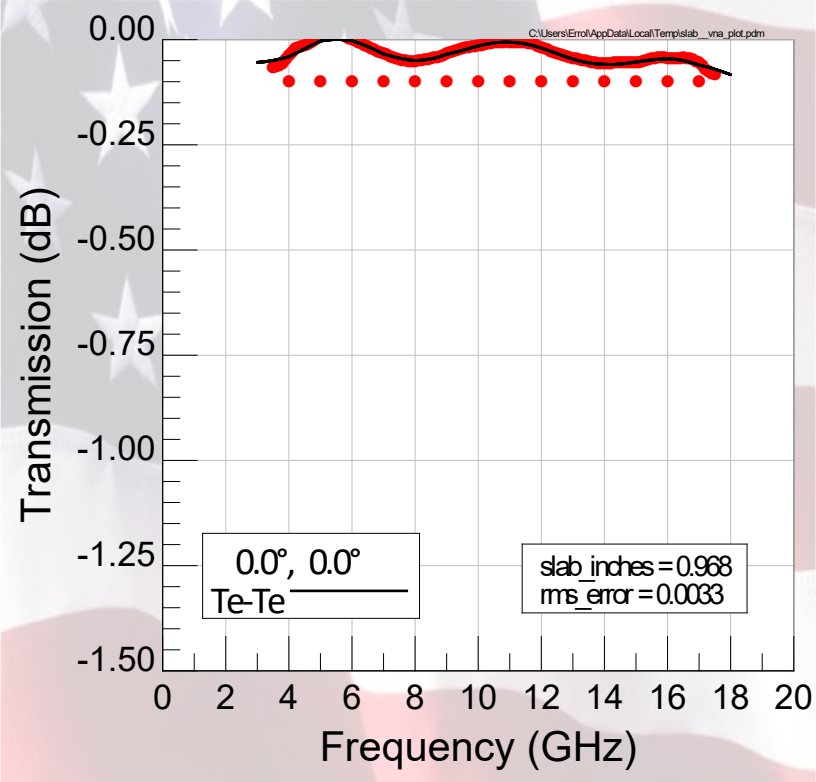
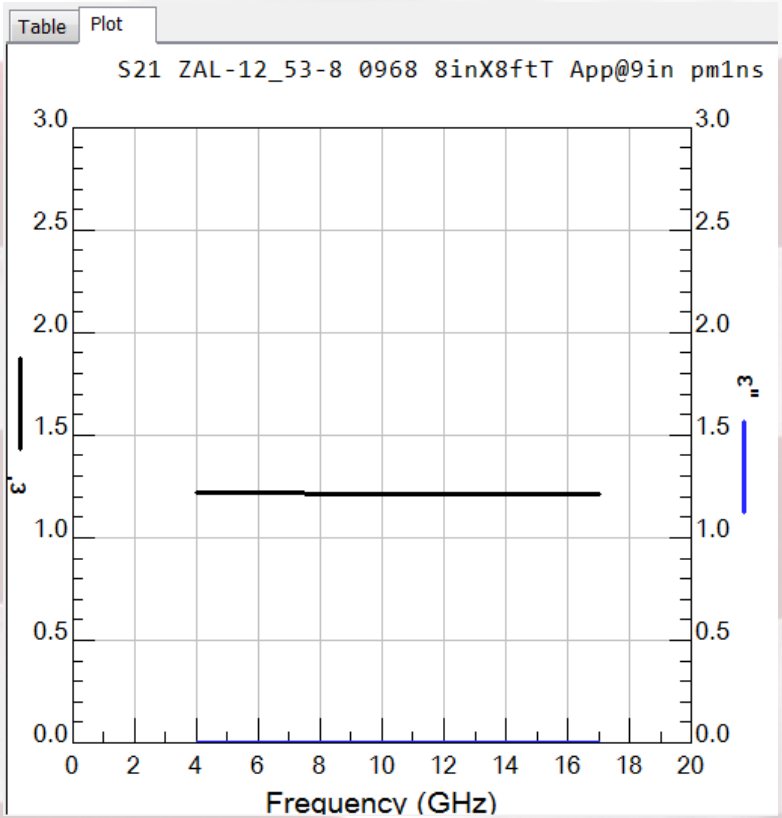
ZAL-12

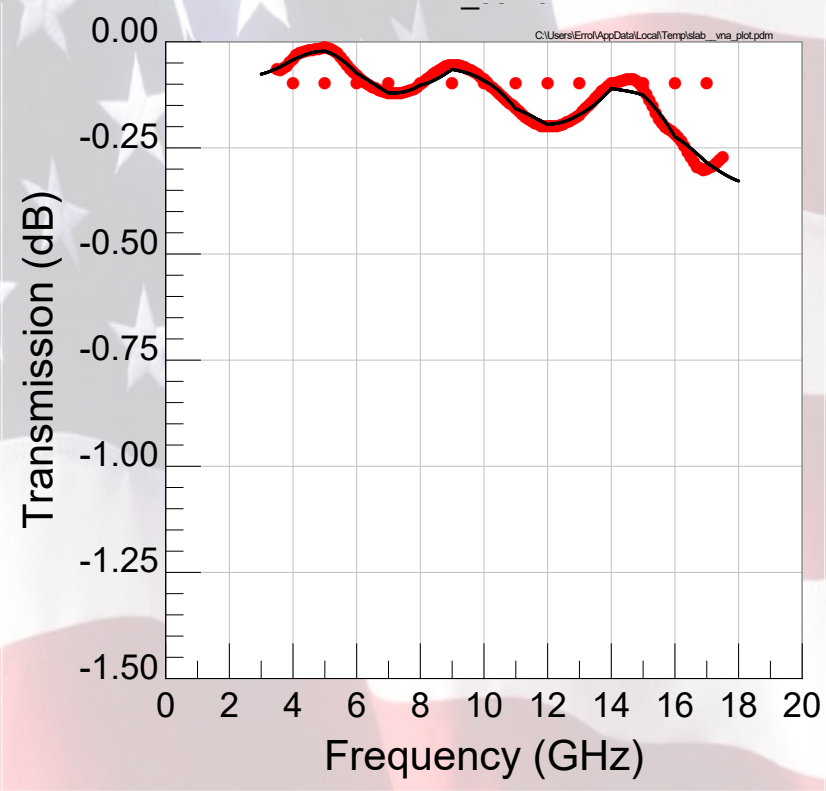
A 12pcf density SiO_2 bonded polycrystalline Al_2O_3 fiber product.

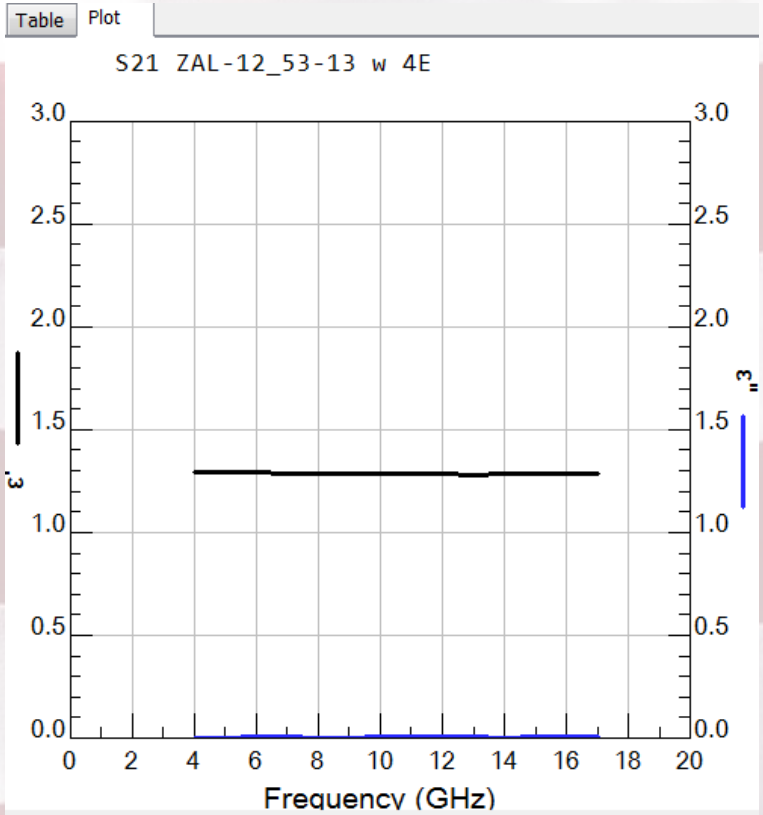




ZAL-12

A 12pcf density SiO_2 bonded polycrystalline Al_2O_3 fiber product, coated with Alumina Cement Type AL-CEM





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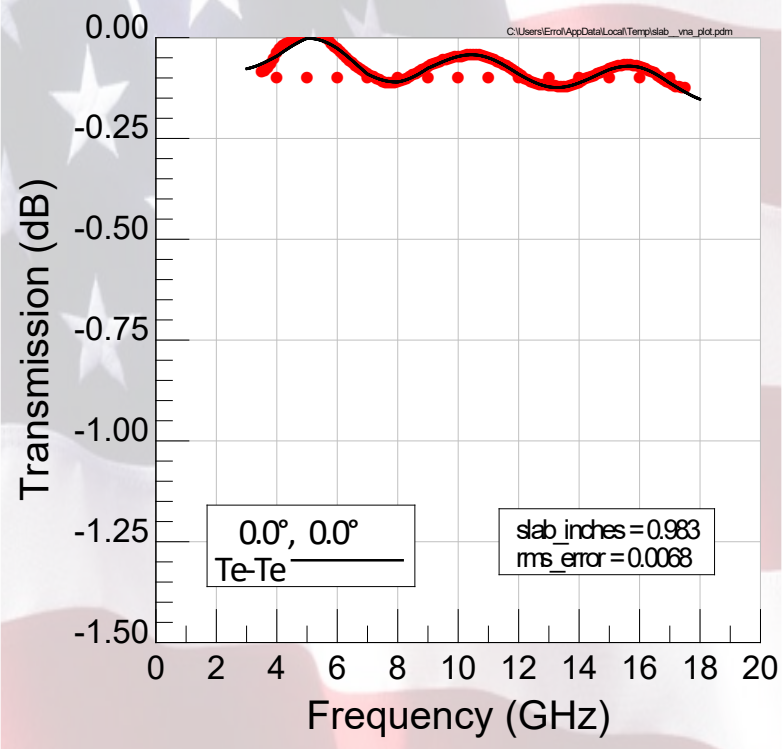
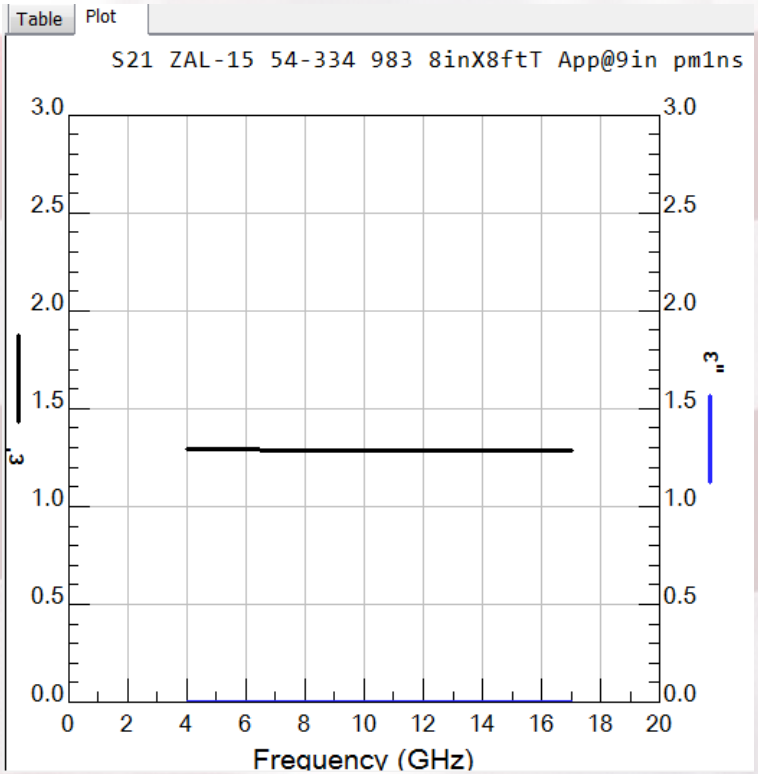
ZAL-15

A 15pcf density SiO_2 bonded polycrystalline Al_2O_3 fiber product.





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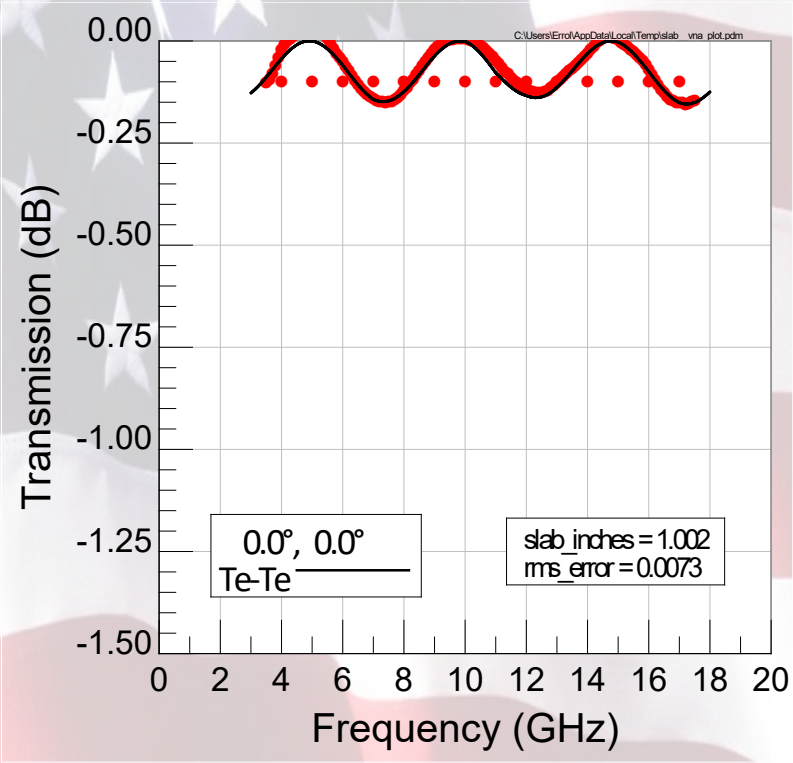
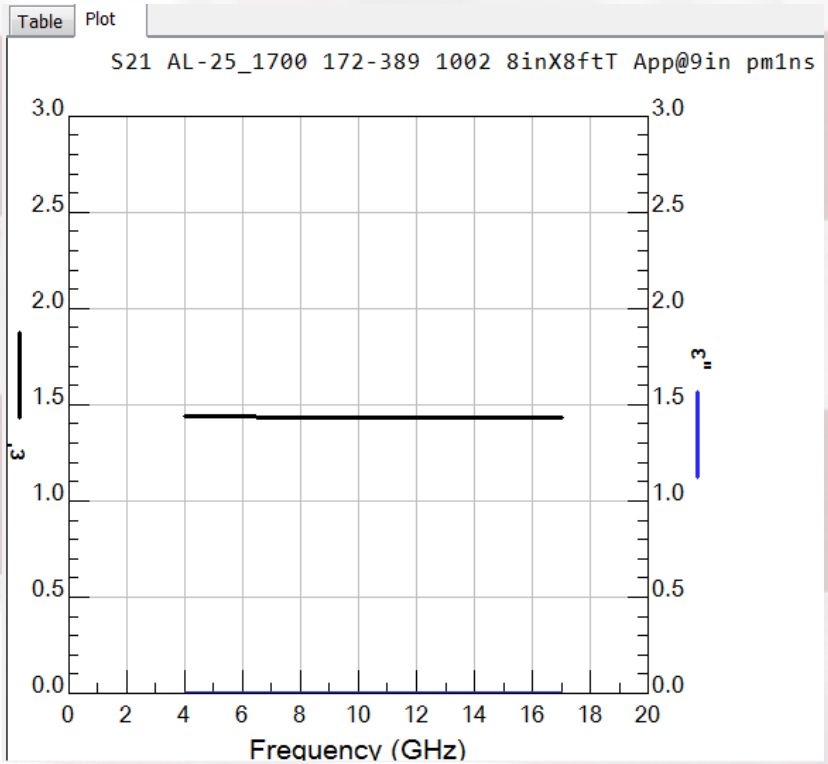
AL-25/1700

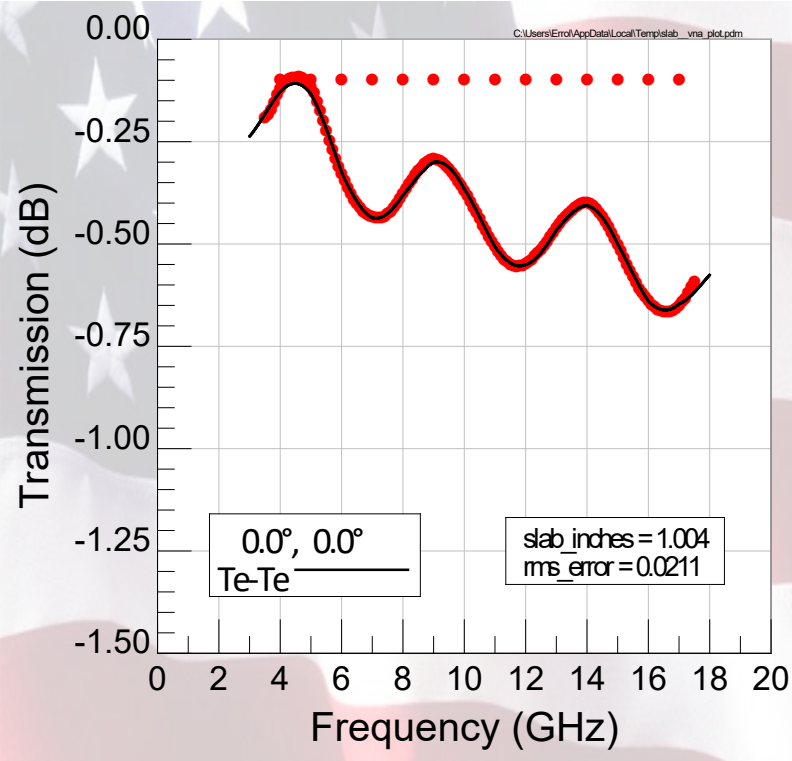
A 25pcf density SiO_2 bonded, polycrystalline Al_2O_3 fiber product.

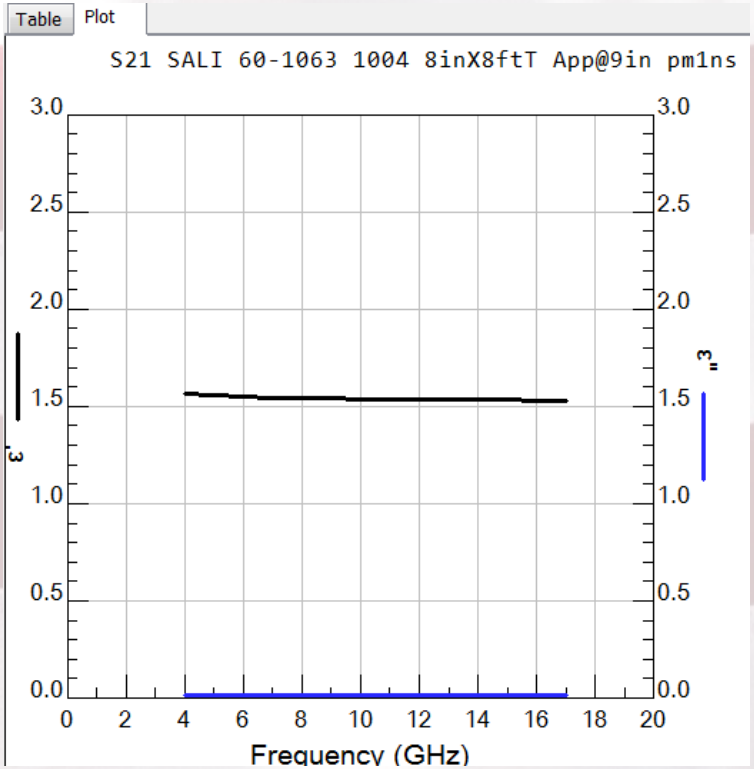




SALI

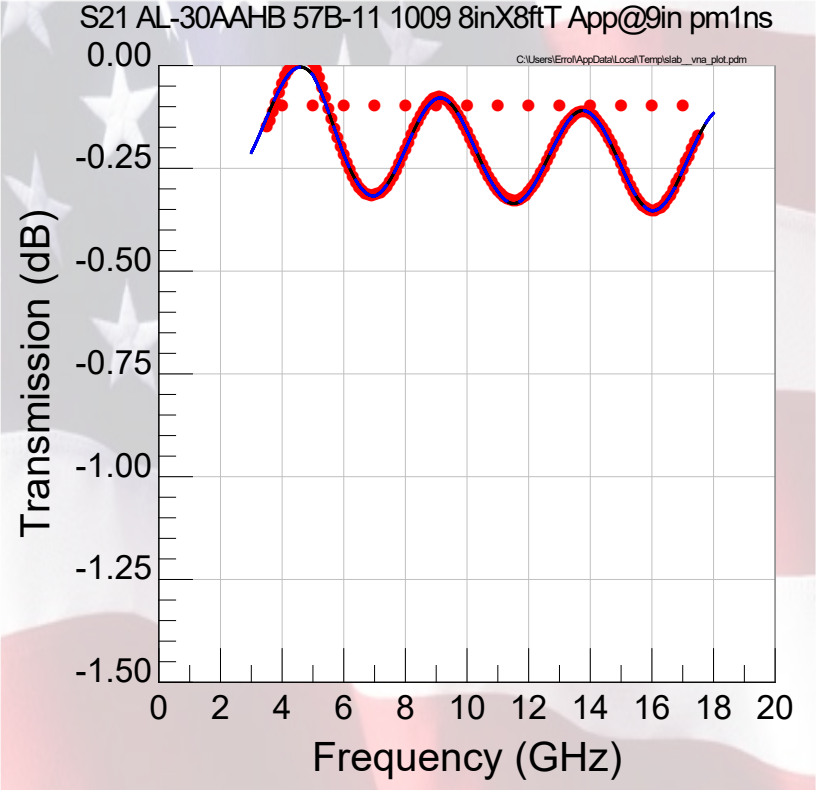
A 30pcf density SiO_2 bonded, polycrystalline Al_2O_3 fiber product.

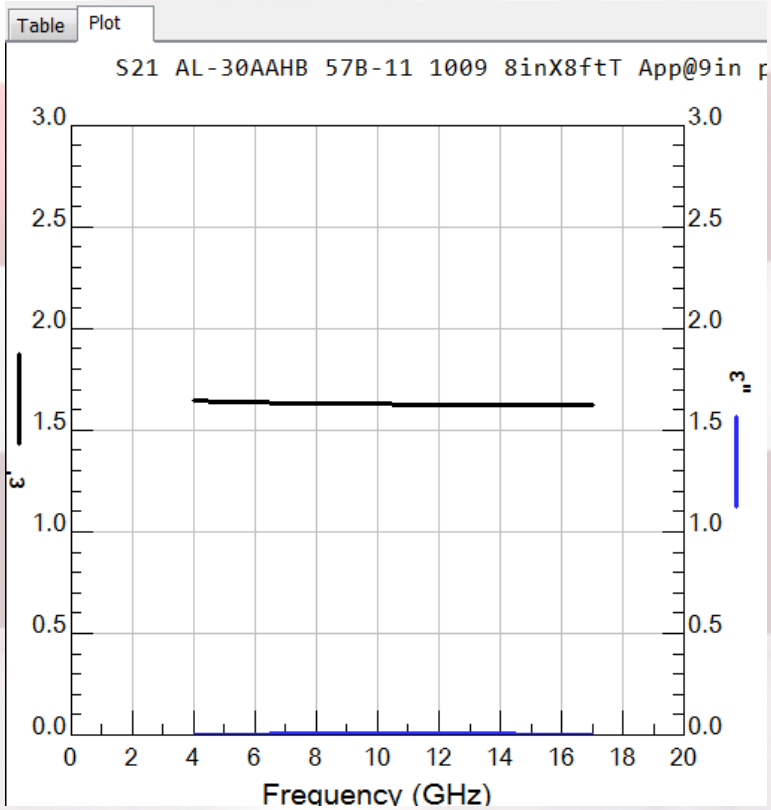




AL-30AAHB

A 30pcf density Al_2O_3 bonded, polycrystalline Al_2O_3 fiber product.





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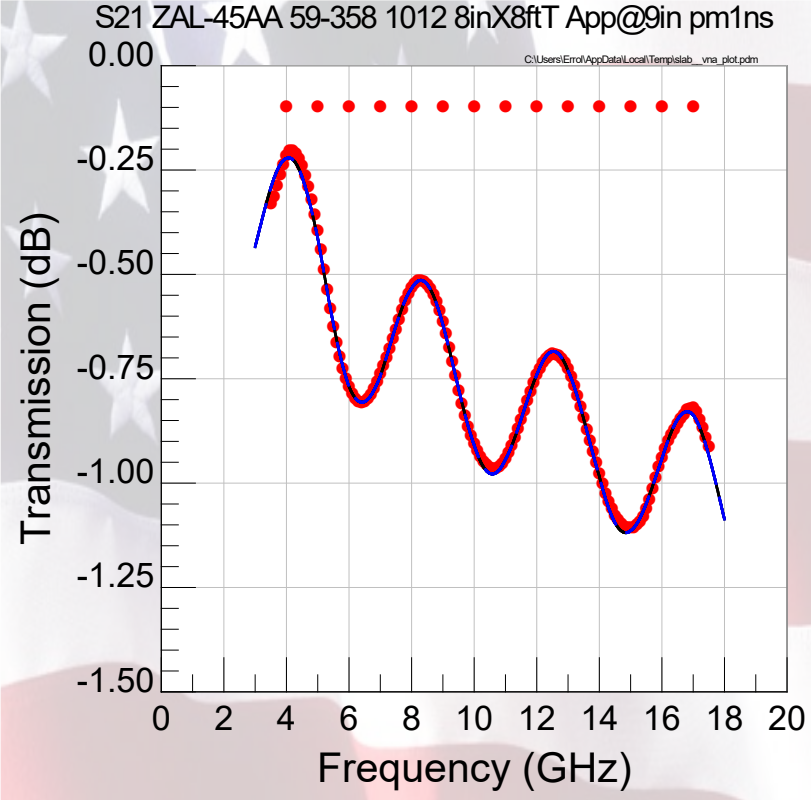
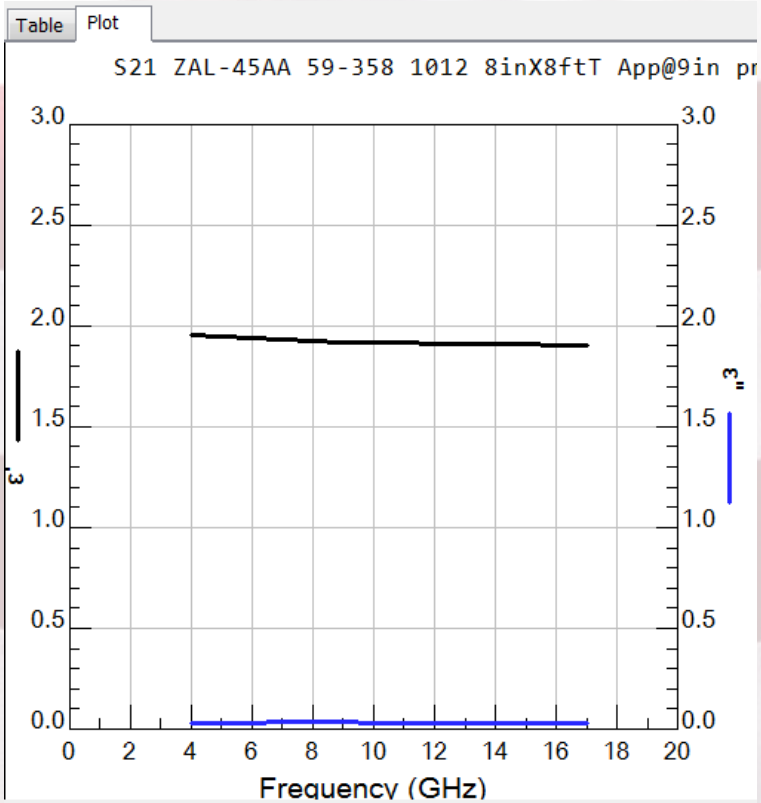
ZAL-45AA

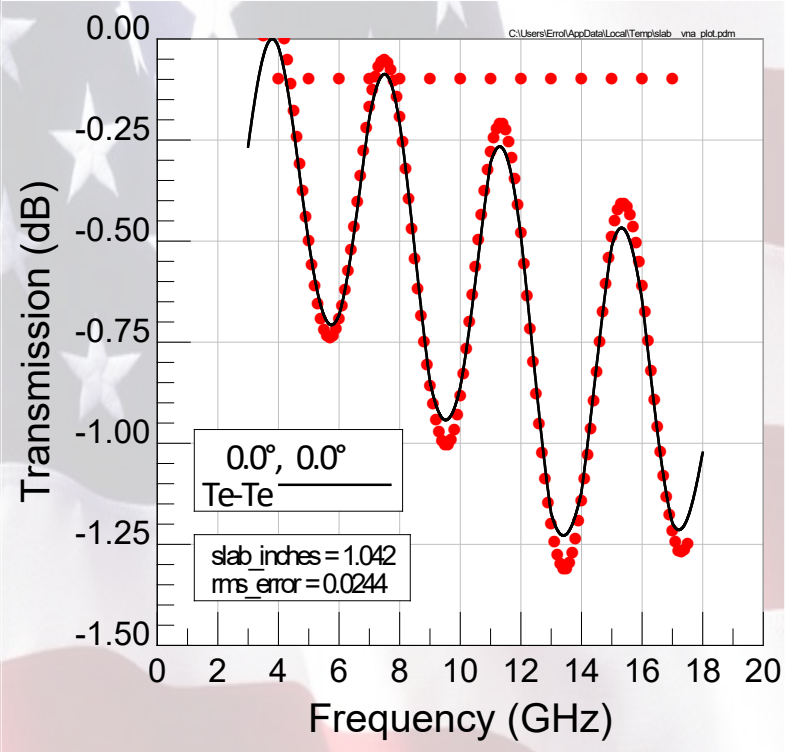
A 45pcf density Al_2O_3 bonded, polycrystalline Al_2O_3 fiber product.

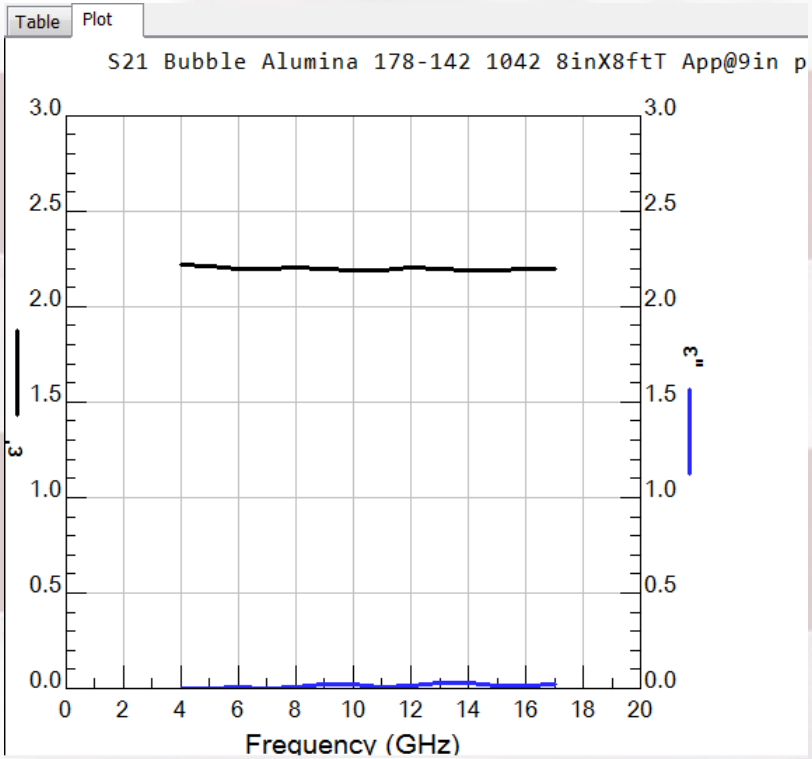




Bubble Alumina

A 60pcf density Al_2O_3 cemented, Al_2O_3 bubble product.





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Permittivity Data Summary

ZIRCAR Ceramics Alumina Type	Nominal Composition, W%, Al_2O_3/SiO_2	Nominal Density, pcf (g/cc)	T, inch (mm)	ε' (4 GHz)	ε' (17 GHz)	ε'' (ave)
ZAL-12	85/15	12 (0.19)	0.968 (24.587)	1.22	1.21	0.001
ZAL-12/AL-CEM*	85/15	12 (0.19)	0.995 (25.273)	1.29	1.28	0.004
ZAL-15	85/15	15 (0.24)	0.983 in (24.968)	1.29	1.28	0.002
AL-25/1700	80/20	25(0.40)	1.002 in (25.451)	1.44	1.43	0.000
SALI	80/20	30 (0.48)	1.004 in (25.502)	1.56	1.53	0.015
AL-30AAHB	98.4/1.6	30 (0.96)	1.009 in (25.629)	1.64	1.62	0.002
ZAL-45AA	97/3	45 (0.72)	1.012 in (25.705)	1.95	1.90	0.015
Bubble Alumina	99+	60 (0.96)	1.042 in (26.467)	2.22	2.19	0.019

* AL-CEM is a 99+% alumina coating – more information HERE!

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Future Work

Lower Frequency – 2.45 GHz

High Temperature – RT to 1400C

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Thank you for your interest in ZIRCAR Ceramics, Inc.

- Please see www.zircarceramics.com for further information on ZAL-15, AL-25/1700, SALI, Bubble Alumina, ZAL-45AA and AL-30AAH. Contact ZIRCAR Ceramics for additional information on ZAL-12.
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