Beamline RF Absorber Materials

E. Chojnacki

HOM - 2010

Carbon Nanotubes

Broadband RF loss demonstrated by mixing CNTs in resins, 1%-10% by wgt
ε' and ε'' increases rapidly as the CNT weight % increases

13696 *J. Phys. Chem. C* **2007,** *111,* 13696–13700

Microwave Absorption of Single-Walled Carbon Nanotubes/Soluble Cross-Linked Polyurethane Composites

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Key Laboratory of Functional Polymer Materials and Center for Nanoscale Science and Technology,
Inst ... The College of Physics,
Nan ... se Academy of Sciences,
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Rec

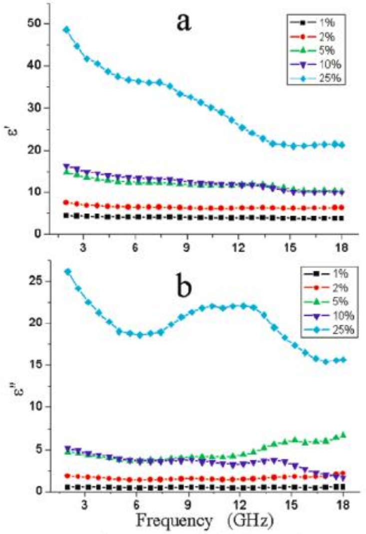

Figure 5. Real (ϵ') (a) and imaginary (ϵ'') (b) parts of the relative complex permittivity of SWNTs/SCPU composites with different loadings.

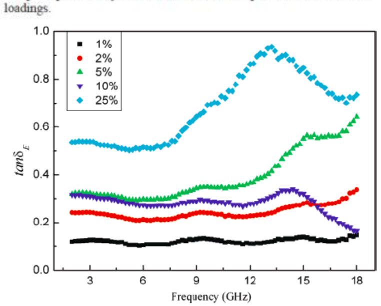

Figure 7. Dielectric loss ($\tan \delta_E = \epsilon''/\epsilon'$) of the SWNT/PCPU samples in the microwave frequency range.

Carbon Nanotube Composites for Broadband Microwave Absorbing Materials

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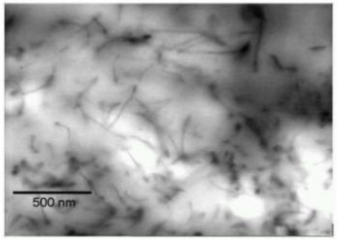


Fig. 10. TEM micrograph for the PCL nanocomposite containing 1.0 weight % of CNTs.

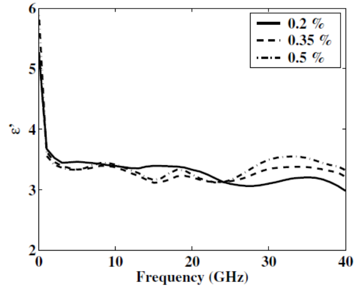


Fig. 5. Real part of the effective permittivity of CNT-poly(ϵ-caprolactone) (PCL) composite with 0.2 (solid line), 0.35 (dashed line), and 0.5 (dash-doted line) weight percent of CNTs.

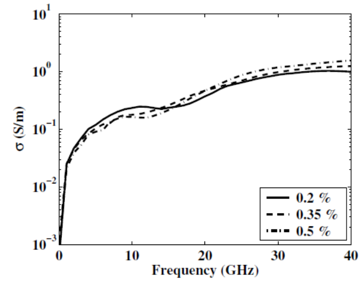


Fig. 6. RF conductivity of CNT-poly(ϵ-caprolactone) (PCL) composite with 0.2 (solid line), 0.35 (dashed line), and 0.5 (dash-doted line) weight percent of CNTs.

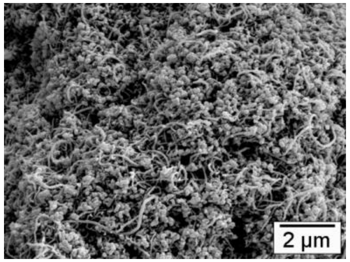
CNTs in alumna ceramic

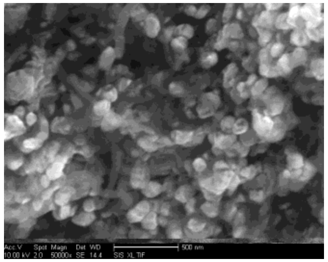
Collaborated with UC Davis Materials Engineering to test CNTs in alumina
Q. Huang, T.B. Holland and A.K. Mukherjee, University of California, Davis

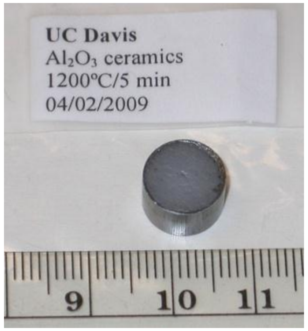
Used an SPS sintering tool

The technology is presently limited to "aspirin" sized samples due to the high current density sent through the sample

Carbon nanotube/alumina composites
Highly-uniform dispersion of carbon nanotubes

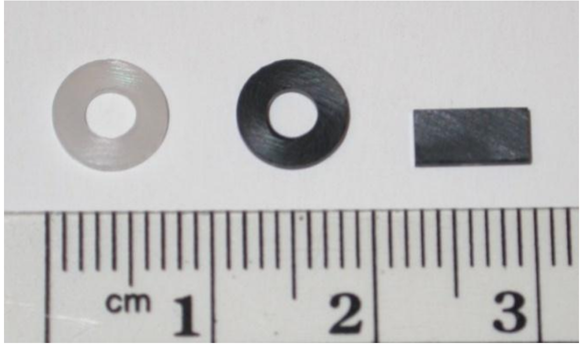




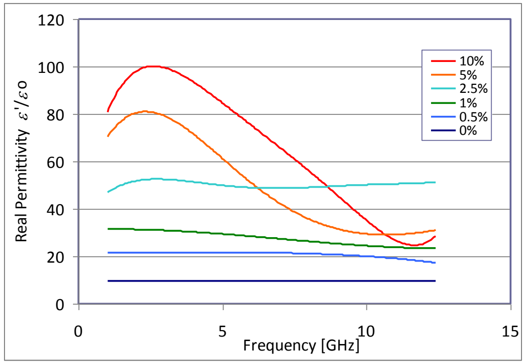


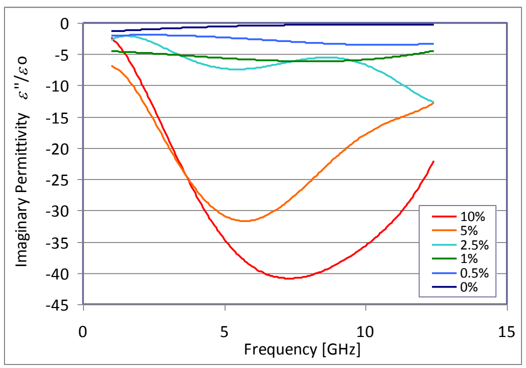
High bulk density: full density

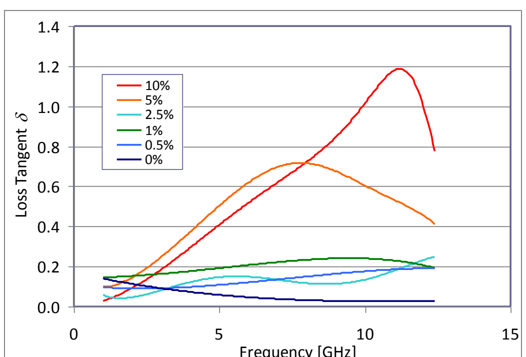
	pure alumina	0.5 wt% composite	1 wt% composite	2.5 wt% composite	5 wt% composite	10 wt% composite
real density	3.968	3.953	3.92	3.843	3.754	3.686
theoretical density	3.96	3.94	3.921	3.865	3.775	3.6
relative density	100.20%	100.30%	99.97%	99.43%	99.44%	102.40%



Measurements of SPS samples







Confirm that ε' and ε'' increases rapidly as the CNT weight % increases

(~30% error bars)

MWCNT Percolation Threshold 0.5% - 1%
establishes DC conductivity insensitive to temperature

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Electromagnetic properties of composites containing elongated conducting inclusions

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(Received 3 May 1995; revised manuscript received 25 September 1995)

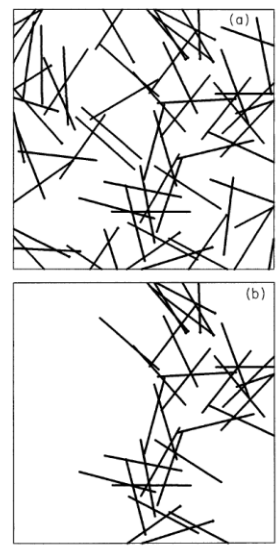
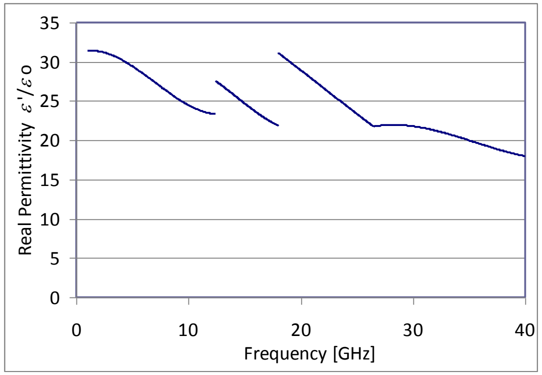
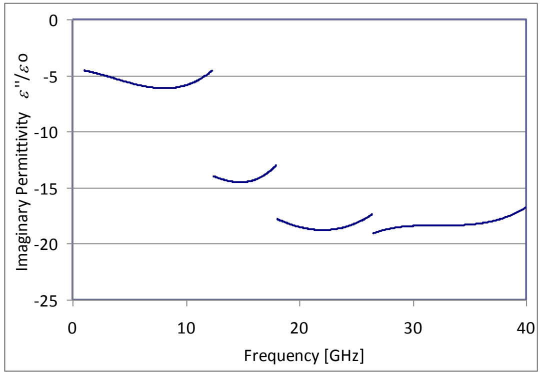


FIG. 1. Conducting stick composite. (b) Backbone of the "infinite cluster" that spans from top to bottom.

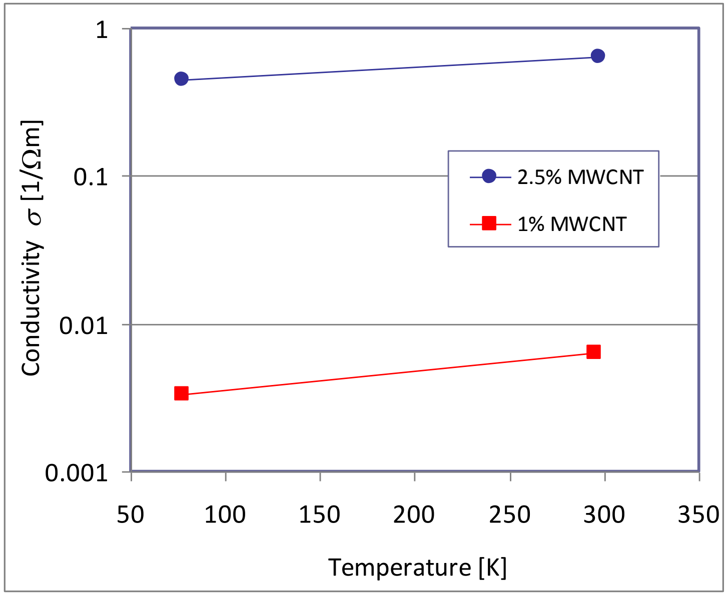
Broadband & DC Measurements

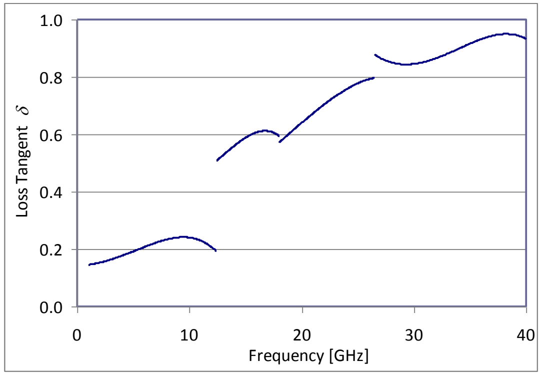


Alumina-MWCNT 1%-2% by wgt yields about the best RF properties (See N. Valles presentation)

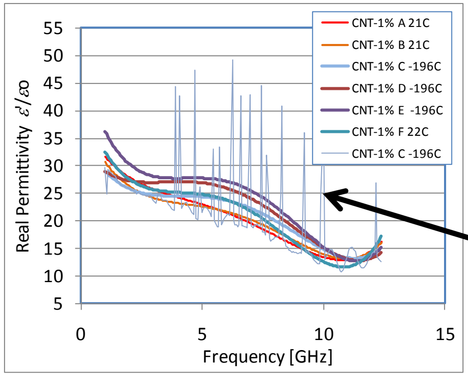


Electrical DC Conductivity





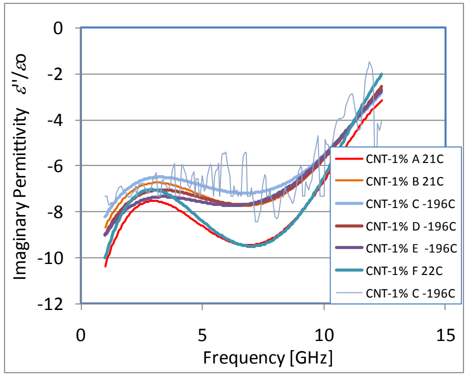
80K Measurement

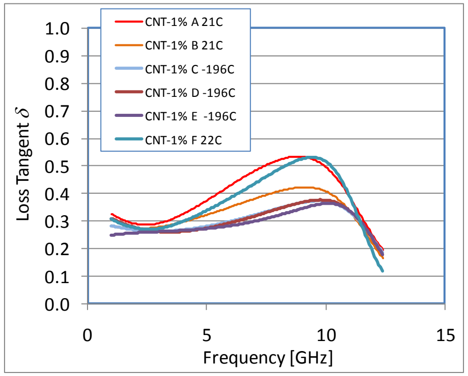


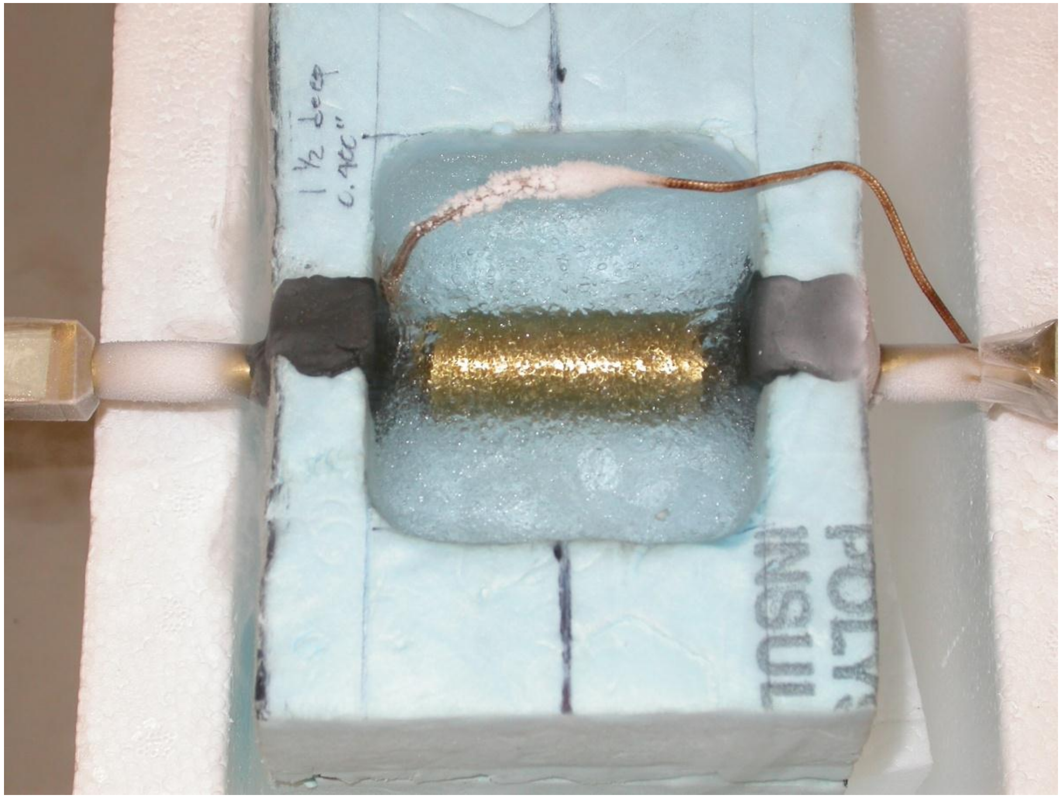
CNT-1% properties are consistent at 21C and -196C (77K)

(~30% error bars)

unsmoothed data







Alumuna-CNT

The next step for ceramic-CNTs is to work with industry to produce large pieces using an amenable sintering process.

The Cornell University ERL Phase 1b effort is supporting this effort at:

- Alfred University, NanoMaterials Innovation Center
- SPHERIC Technologies, Inc.

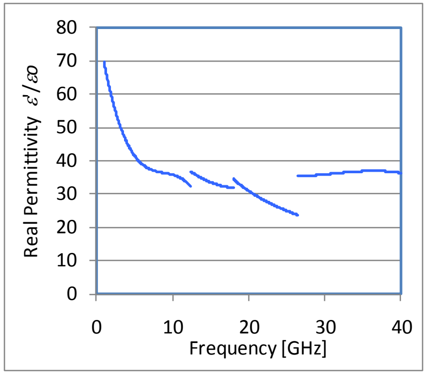
SiC

F. Marhauser @ JLAB kindly provided a sample wedge of SiC with graphite loading available from Coorstek

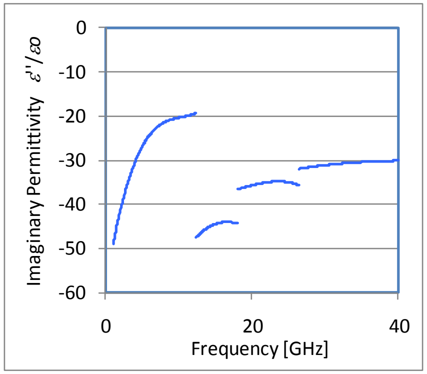
Similar phenomenon as with CNTs, increase in ε and DC conductivity, but the smaller graphite particles require higher weight % loading (>= 8%?)

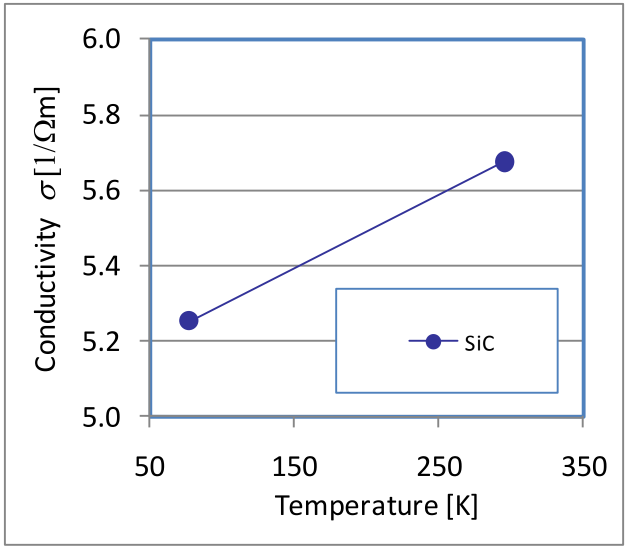
Unlikely that Coorstek will vary the recipe to tune RF properties

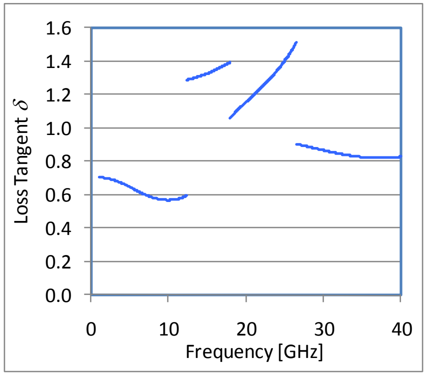
SiC



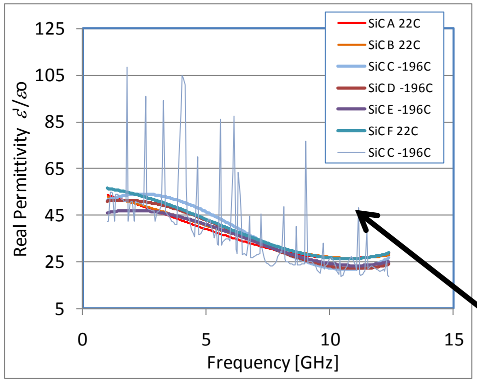
Measurements show some suspicious behavior, indicating large measurement error, or inhomogeneities in the material and ghost modes.







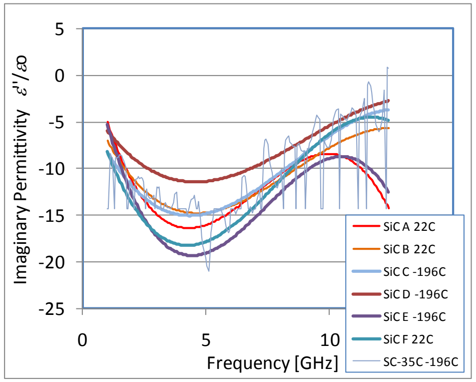
SiC 80K Measurement

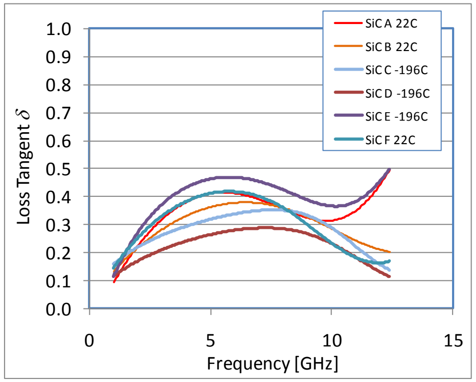


SiC properties are consistent at 21C and -196C (77K)

Also passes a qualitative test using a tile in foam cup in microwave oven (2.46 GHz) ~ 3 sec

unsmoothed data





SiC Next Steps

- Use Coorstek Si-C in the next-generation ERL beamline HOM load
- Cylinders delivered, 110mm ID, 120mm OD, 140mm Long
- Broadband RF loss, $\varepsilon \sim 50 - i25$, not the ideal absorber, but the best available today
- Sufficient DC conductivity @ 80K
- No measured particulate generation
- Vacuum properties acceptable