

# Hybrid Polymeric Composites with Nanopowders Filled Matrix

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## Classification and Characteristics of Composite Materials

1. Fibrous composite materials that consist in fibers in a matrix
2. Laminated composite materials that consist of layers of various materials
3. Particulate composite materials that are composed of particles in a matrix
4. Combinations of some or all the first three types [1]

## Forming Composites There Might be Improved

•strength, •stiffness, •corrosion resistance, •wear resistance, •attractiveness, •weight, •fatigue life, •temperature-dependent behavior, •thermal insulation, •thermal conductivity, •acoustical insulation, •electric conductivity, •electromagnetic behavior.

## Aims of Composites Forming

- replacing metals in spacecraft and aircraft industries
- applications for highly aggressive media

## Formed Samples

laminated hybrid composites with kevlar and carbon fiber fabric reinforcement and filled epoxy matrix [2]

## Forming Technique

combined method, first a “layer-by-layer” adding of resin imbued sheets of reinforcement. After the mould was closed the excess of resin was extracted through application of a mechanical effort, then the mould was introduced in a rubber bag; the air and other gases from the bag were removed using a small vacuum pump in order to avoid the gas intrusions in the sample (c-i)

## Aims

- changing the basic electric properties of standard material (a)
- improving the mechanic properties of basic composite



## Challenges

- ensuring the reinforcement-matrix interface while the reinforcement is combining the properties of kevlar and carbon fiber
- ensuring the dispersion of nanosized particles in resin volume and avoiding their clusterization [5]
- changing the electromagnetic properties of materials [7]

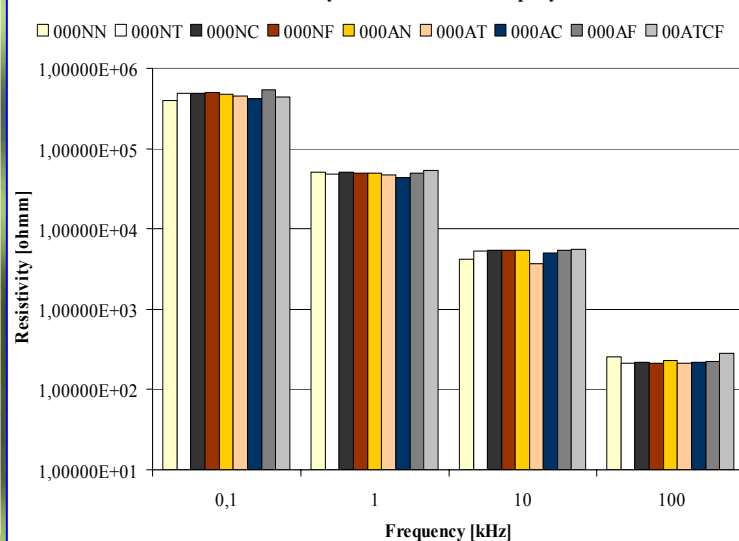
## Solutions

- depositing a thin film of PNB rubber on the fabric; meantime ensuring the integrity of fabric during the technologic process [3], [4]
- adding a small amount of clay in preparation of powders [6]
- adding small amounts of nanosized ferrite, talc, CNT [8]

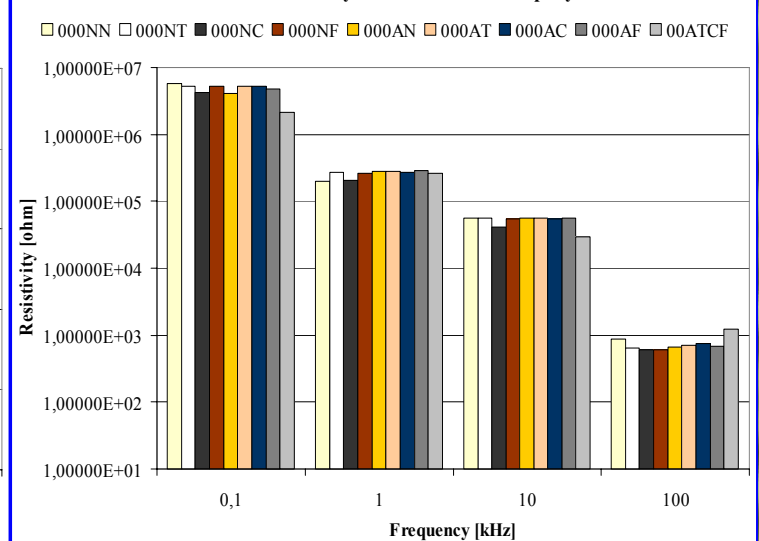
## Measurements

For each sample electric resistance, electric capacitance and electric inductance were measured using a technique described in [9]. Bulk resistivity and surface resistivity were evaluated accordingly to *STAS 6108/71, Rezistivitatea plăcilor*. All the measurements were done using a RLC meter and the 4 wire method. The measurement cell geometry is respecting the requirements of an accurate measurement, according to [7] and they are:  $r_1 = 27,4mm$ ,  $r_2 = 30,2mm$ ,  $r_3 = 45,6mm$ .

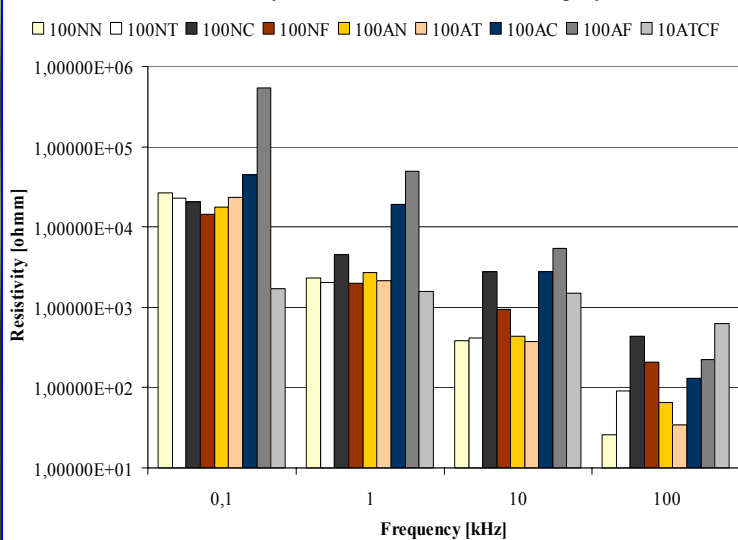
Bulk Resistivity of Pure and Filled Epoxy



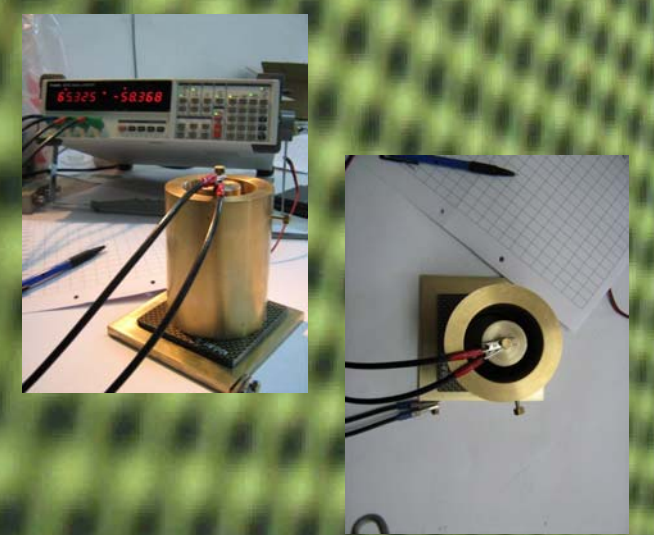
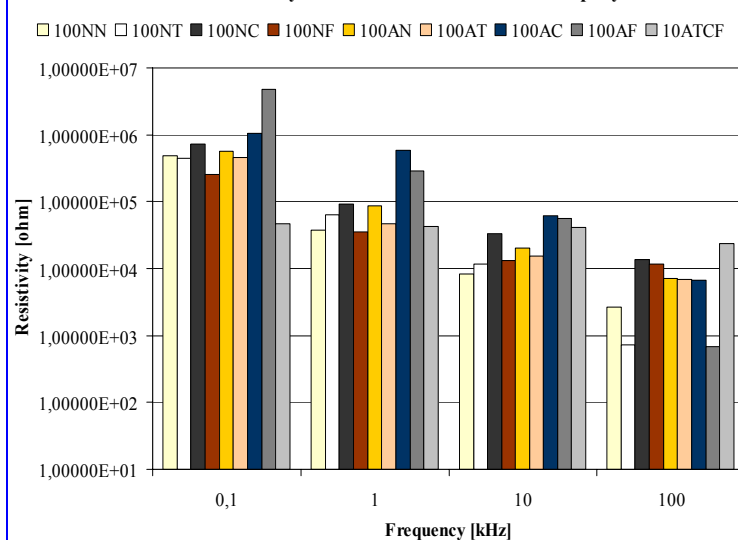
Surface Resistivity of Pure and Filled Epoxy



Bulk Resistivity of Reinforced Pure and Filled Epoxy



Surface Resistivity of Reinforced Pure and Filled Epoxy



## References

- [1] Jones, R., *Mechanics of Composite Materials*, Taylor&Francis, 1999.
- [2] Cîrciumaru, A., Andrei, G., Bîrsan, I.-G., *Electric and electromagnetic Properties of Fiber Fabric Based Filled Epoxy Composites*, Proceeding of the 1<sup>st</sup> International Conference on Polymers Processing in Engineering, Galați, 2007, pp. 212-222.
- [3] Cîrciumaru, A., Andrei, G., Bîrsan, I.-G., Dima, D., *Electric and electromagnetic Properties of Fiber Fabric Based Filled Epoxy Composites*, The Annals of “Dunărea de Jos” University of Galați, Fascicle IX, Faculty of Metallurgy and Materials Science, XXV (XXX), May 2007, no. 1, pp. 97-102.
- [4] Kim, J.-K., Mai, Y.-W., *Engineered Interfaces in Fiber Reinforced Composites*, Elsevier, 1998.
- [5] Krishnamoorti, R., *Strategies for Dispersing Nanoparticles in Polymers*, MRS Bulletin, 32, 2007.
- [6] Hunter, D., Kamena, K., Paul, D., *Processing and Properties of Polymers Modified by Clays*, MRS Bulletin, 32, 2007.
- [7] Lhyshevski, S. E. (ed), *Nano and Molecular Electronics Handbook*, CRC Press, 2007.
- [8] Advani, S., *Processing and properties of Nanocomposites*, World Scientific Publishing, 2007.
- [9] Webster, J. G. (ed), *Measurements, Instrumentations, and Sensors*, CRC Press, 1999.

## Samples

In the legends first digit 0 or 1 refers to the absence or presence of reinforcement (15 sheets); NN denotes pure resin; the fourth digit A means that the epoxy is clay modified; the fifth digit values are: T (for talc), C (for CNT), F (for ferrite) used as fillers (same concentration for each one). The last samples are formed using all the nanopowders as fillers (same concentration for each one). The reinforcement is made by alternating sheets of prepared fabric, the odd sheets have warp and fill parallel to the mould, edges while the even ones have the warp and fill oriented at 45 degrees reported to mould edges.