

11th IYPT '98
solution to the problem no. 12
presented by the team of Slovakia
Vladimír Koutný

Powder conductivity

Measure and explain the conductivity of a mixture of metallic and dielectric powders with various proportions of the two components.

Abstract

In this article I will try to explain you the main idea of our approach to this task, as well as explanation of how to succesfully simulate this phenomenon using a computer.

Thanks

Thanks to Richard Královič for the computer simulation

Overview

- Measurements and simulation

1 Measurements and simulation

When we want to measure the conductivity of the mixture, we can also measure its resistance. The problem is that if you measure the same mixture under different pressures, you get different results and therefore you are not able to say one result which would be exact. We made more measurements and we found out that when there is less than about 30% of metallic particles in the mixture, the whole mixture is not conductive.

Because exact measurements of resistance are not easy to perform, we tried to make a model of this mixture instead. Let's suppose that both metallic and dielectric particles have the same size and that they are positioned along a cubic grid. Then each particle has 6 neighbours. If two neighbouring particles are both metallic, we can imagine a resistor between them, otherwise we can say that there is not any resistor. Now we have a grid of resistors and our task is to compute its resistance.

For this task we used a computer simulation. This simulation was done on a grid of $8 \times 8 \times 8$ particles with different proportions of metallic and dielectric particles. In the next table we can see the resistances of mixtures with different proportions of particles:

Proportion	ϱ [m Ω m]
1.00	0.44
0.95	0.47
0.90	0.53
0.85	0.55
0.80	0.64
0.75	0.72
0.70	0.82
0.65	0.99
0.60	1.15

Proportion	ϱ [m Ω m]
0.55	1.39
0.50	1.92
0.45	2.58
0.40	4.45
0.35	21.50
0.30	23.55
0.25	36.92
0.20	-
0.15	-

We can see from this table that if there is less than 25% of metallic particles the whole mixture becomes a dielectricum, what is similar result as in our experiment.

In the simulation we assume the voltage between two ends of the grid. Then we choose either a way from one to second end (in this case we change the currents on all resistors on the way so we get the required voltage) or a closed circular way (here we change currents so the voltage on this way is zero). We repeat this step many times and we get approximating value of resistance of the mixture.