STRUCTURE AND PHYSICAL PROPERTIES OF CARBON–CARBON COMPOSITES

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ABSTRACT

The interrelation between the structure and some physical properties of carbon–carbon composites reinforced by carbon fibres was studied. The matrix produced from coal–tar pitch in these composites heat treated at 2100°C near the fibres surface has an axial symmetrical texture and its crystalline microstructure is more perfect than that of carbon fibres. The Young's modulus values and thermal conductivity of the matrix in unidimensional composites were determined. The matrix Young's modulus dependence on the texture parameter \(<\sin^2\theta>\) is similar to that of carbon fibres. The matrix thermal conductivity depends mainly on the microstructure perfection. The matrix structure effect on some properties of uni- and four-dimensional composites was shown.

The physical properties of carbon–carbon composites based on carbon fibres and carbon matrix are determined by properties of components, reinforcing type and etc. In the present work the interrelation between the structure of matrix produced from coal–tar pitch in carbon–carbon composites reinforced by carbon fibre tows and some physical properties of these composites was studied. Carbon fibres based on polyacrylonitrile precursor and prepared at a higher temperature than the composites were used as fillers. The magnetoresistivity of carbon fibre filaments extracted from these composites was studied at helium temperatures. The magnetoresistivity dependence for these filaments on magnetic field intensity up to 5 Tesla was the same as that for carbon fibres heat treated at the same temperatures as the composites. So the conclusion was made that the matrix influence on the filler properties and structure in these composites...
was inessential and a simple additive model for calculating some properties may be used.

It was found that the matrix near the fibre surface has an axial symmetric texture and its texture parameter $<\sin^2 \theta>$ determined from measurements of magnetic susceptibility was lower than for carbon fibres used as fillers, and the value of $<\sin^2 \theta>$ decreased with increasing the matrix thickness on the surface of fibres. At the same time the average value of matrix diamagnetic susceptibility was higher than that for carbon fibres. That was the evidence of a higher perfection of the matrix microstructure (higher crystallite sizes) than that for the filler. The matrix thickness (total matrix content in composites) increased due a several successive cycles of pitch impregnation and heat treatment at high temperatures. The coefficient of connectedness $K_z$ [1] determinated as the relation of measured electrical conductivity at low temperatures to electrical conductivity of the poreless volumes was used as a characteristic of the matrix macrostructure.

The matrix Young's modulus values for unidimensional composites was calculated on basis of measurements of the fibre and composite Young's modulus using the simple additive model. In view of lower texture parameter $<\sin^2 \theta>$, the matrix Young's modulus in the unidimensional composites is lower than that of the filler. So the matrix contribution to the Young's modulus values of these composites was not so important. The dependece of reduced Young's modulus for matrix $E/K_z$ on its texture parameter may be described by the same expresion as for carbon fibres [2].

The matrix thermal conductivity in the unidimensional composites is essentially higher than for the filler. Because that the thermal conductivity of these composites in the reinforcing direction is essentially determated by the matrix thermal conductivity. High values of the matrix thermal conductivity is due to relatively large crystallite sizes in the basal plane (for matrix $L_a \approx 300 \, \text{Å}$, for fibres $L_a \approx 60 \, \text{Å}$).

The structure and Young's modulus of four-dimensional composites were studied. The reinforcement of these materials was realized by the same carbon fiber tows in directions of space diagonals of