The decoded model of transcrystallinity in carbon and aramid fibers reinforced nylon 66 composites by by Synchrotron study

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Thermoplastic composite materials offer significant advantages over well established thermosetting systems, in that commodity materials such as polyolefins and nylons, can be used and adapted to meet more demanding design specifications without resorting to more expensive polymer systems.

Thermoplastic matrices may be partially crystalline and the degree of crystallinity, as well as the physical order of the polymeric matrix, is expected to play a major role in determining the mechanical performance of the composite.

In the case of semicrystalline thermoplastic polymers, it is proven that the matrix is greatly affected by the presence of the fiber. A fiber, which is embedded in a thermoplastic polymer melt, may act as a heterogeneous nucleation agent for spherulite growth. If many nucleation sites are present on the fiber surface, the resulting spherulite growth will be restricted in the lateral direction, so that a columnar layer, known as transcrystalline layer (tc-layer), will develop and enclose the fiber. One of the most interesting questions was the microstructure of tc-layer and its orientation. The solution is been suggested in this work.

In this study carbon and aramid fibers were used to produce unidirectional nylon 66 based composites. The transcrystallinity generated around the fibers was characterized by SEM and polarized light microscopy. The main study of tc-layer structure and orientation was studied after an experimental work at ESRF (European Synchrotron Radiation Facility – ID-11), wherein the samples were exposed to intense X-ray microbeam, scanning in 2μm steps across the full width of transcrystalline layer. The preliminary results corresponded tightly to the microscopic observations, expressing a well-defined orientation of the crystalline lamellae in the tc-layer. Several types of aramid and carbon fibers were analyzed and different transcrystalline orientations were observed for each microcomposite system. The microstructure of transcrystallinity was suggested.