Super Thermal Conductivity Increase of Microscale Silkworm Silk under Stretching

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Silkworm silk has been used for thousands of years for clothing and decoration. To date, no work has been done about its thermal transport capability in the axial direction although some work has been reported about the thermal conductivity of cloth (in the thickness direction) made of silkworm silks. In this work, we report on the first time ever measurement of the thermal conductivity of raw silkworm silks in the axial direction. The reported silkworm silk has a diameter of about 10 micrometers. Most excitingly, we stretch the silk and investigate how the thermal conductivity changes under stretching. We find that the thermal conductivity of silkworm silk increases quickly under stretching, contrary to normal materials that their thermal conductivity will decrease when being stretched. When the silkworm silk is stretched by 100%, the thermal conductivity increase is more than 200%; this represents the largest thermal conductivity increase and tunability for organic materials. Also thermal failure is observed before the silk breaks. The helical structures and beta-sheet crystals inside the silk are taken into account to explain this new phenomenon.