Sensitive Synthetic Skin for Prosthetic Arms

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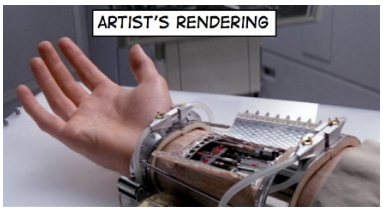
Prosthetics have been around for a while now and they are continually being upgraded and remodeled to look and function as close to a real limb as possible. That goal is closer than ever with the sensitive synthetic skin being created by the prosthetics program of the Defense Advanced Research Projects Agency (DARPA). Researchers have created a material by combining carbon nanotubes with a specially designed polymer, that has the appearance of human skin and together with the prosthetic arm will feel and function like human skin too. The synthetic skin could lead to next-generation prosthetic arms with which users can feel a light touch, shake hands, cook, and type naturally because the arm will send signals to the brain and in turn respond to brain signals.

The skin itself is a rubbery polymer called polyimide that has been infused with tiny carbon nanotubes. Initially designed for airplane pressure sensors, the polymer is durable, resistant to high temperatures, and piezoelectric, which means that it generates electricity in response to pressure or force.
The carbon nanotubes will enhance the piezoelectricity of the polyimide and make the polymer stronger.

Polyimides are incredibly strong and astoundingly heat and chemical resistant polymers. These qualities are so great that these materials often replace glass and metals, such as steel, in many demanding industrial applications They are also used in the construction of many appliances, microwave cookware and food packaging because of their thermal stability, resistance to oils and their transparency to microwave radiation.

Carbon nanotubes are allotropes of carbon with a nanostructure that can have a length-to-diameter ratio greater than 1,000,000. They exhibit extraordinary strength, unique electrical properties, and are efficient conductors of heat which is why they enhance polymer giving it heat sensing capabilities.



To sense temperature, sensors will be embedded under the polyimide layer. The object is to transfer heat as quickly as possible from the polymer surface to the sensors. This will be done by the carbon nanotubes, who conduct heat along their length very well.
In 2006 it was shown that a heat pulse travels 20 times faster in a polymer containing the nanotube arrays than in the pure polymer.

As far as pressure sensing goes, the goal is to have an artificial skin that can measure a force as small as 0.1 newton and a spatial resolution that can differentiate between two pinpricks 2 millimeters apart, however the nanotube composite is not that sensitive yet.

The future goals of this project include getting the brain to respond accurately to these signals sensed by the synthetic skin. The possible solution is to redirect the arm nerves of amputees to their chest muscles, allowing them to use the chest to intuitively control a prosthetic arm and even to feel some pressure applied to the limb. This research is being done by Neuroscientists at the Rehabilitation Institute of Chicago.

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