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Materials Science
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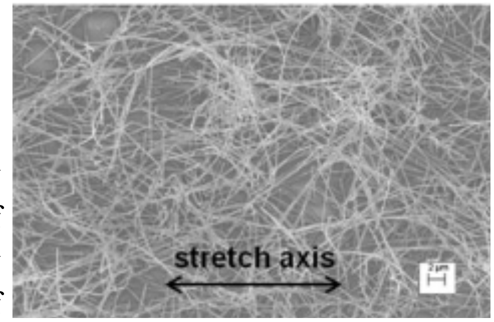
Stretchable, conductive and transparent materials could lead to exciting advances in wearable technologies



Silver nanowire embedded plastics have been previously shown to be conductive and transparent. A development of a new procedure can now add stretchable to this already exciting list of properties. Which the development of stretchable, conductive, transparent materials, the invention of new and innovative wearable electronics looks to be in the near future.

Having your phone screen break is a reality which too many people unfortunately encounter. The conductive, brittle glass of a phone screen will readily break when put under stress. Though there has been drastic development to reinforce the glass, the glass breaking will always be an issue due to the physical nature of glass. Xinning Ho and associates of the Singapore Institute of Manufacturing Technology (2014) may have developed a solution to this problem. They have been researching stretchable, transparent conductors. Not only may this research lead to a phone screen with cannot break the same way glass does, but it also may open to door to the invention of new wearable electronics. The material being studied is a polymer with embedded silver conducting nanowires. There have been previous studies performed which developed a similar product, however, previous studies either did not account for the need for the material to remain conductive when stretched, or when the material is stretched in more than one way. The new method developed will allow for the material to be stretched biaxially and remains conductive.

With the high consumer demand for new and innovative technologies, advances in this field must be made. New technological trends which are gaining considerable media attention are wearable electronics. This field of electronics are certainly in the beginning stages and currently include technologies such as google glass and smart watches which can detect bodily rhythms. The consumer demand for such products are particularly high and the development of new wearable products must be made. The research performed by Ho would have a significant role in wearable electronics. For something worn to be comfortable, yet fitted, there would have to be some stretch to the material. Some materials, such as plastics, obtain this ability due to their amorphous structure. Other materials, such as metals, do not obtain this ability due to their crystalline structure. Plastics would stretch, but are not conductive. Metals are conductive, though they are not stretchable and would not lead to comfortably fitted wearable electronics. The two must be combined in such a way that the metal provides the plastic conductive properties and the plastic provides the metal a wearable and stretchable medium.

If someone had the ability to design the perfect material for a flexible, wearable electronic, silver nanowires would be very close to the imagined material. Its properties make it perfect for the use in flexible electronics. Silver nanowires are highly conductive, this is essential for the efficiency and sensitivity of the electronic device. When a material is conductive, electrons may freely flow through the material with little resistance. The usefulness of silver nanowires far exceeds their conductive capabilities. Silver nanowires are very thin; they range in size but, they are roughly 100 nm in diameter. Their small size makes for the possible production of thin electronic devices. Silver nanowires are also optically transparent, this is the key feature which makes them such an interesting candidate. Since they are transparent, they can be used, in conjunction with some suspension, as a screen for an electronic device.

The purpose of this research was to determine a technique which allows for the production of a conductive material which can be stretched and still remain conductive. In order for the material to remain conductive, the silver nanowires much remain in good contact with each other. The material which was considered was a polymer, polydimethylsiloxane, abbreviated to PDMS, loaded with silver nanowires. Silver nanowires may be transferred to the PDMS by a method referred to as transfer printing. The silver nanowire film forms on a membrane filter, as the membrane filter approaches the PDMS surface, the adhesion of the silver nanowires to the PDMS is greater than the adhesion of the silver nanowires to the membrane filter, and transfer printing occurs. The silver nanowire film would then be attached to the PDMS surface. This would lead to a flexible conductive material, but as the PDMS was stretched, the silver nanowire networks would be torn apart, no longer maintaining good contact with each other and their conductivity would be greatly reduced. To overcome this problem, the idea of pre-stretching the PDMS material before the transfer was developed.

By pre-stretching the material and then preforming the transfer, when the material contracts to its original form, the silver nanowires buckle. This method has been performed before by pre-straining the material in one direction, and it worked well to create a material which is stretchable uniaxially. In order for the material to be able to be stretched biaxially, a new method has been developed by Ho and associates where the material is pre-stretched over a sphere before the silver nanowire transfer. Stretching PDMS over a sphere could lead to uneven stretching over the entire surface of the sphere. This was not an issue however because the sphere used was infinitely large compared to the sample area of the PDMS considered. When the material retracts to its original form, the silver nanowires buckle out of plane. This out of plane buckling allows for the material to be stretched in more than one way and not have any of the silver nanowires tear and reduce the conductivity. However, when the silver nanowires are prepared by this method and buckle out of plane, they pull vertically on each other when stretched in one direction. This results in the loss of contact between the silver nanowires. To overcome this, an addition procedural step was employed. The silver nanowire PDMS material prepared as previously stated was then hot pressed with a temperature of 100C and pressure 4 MPa for 10 seconds. This process presses the nanowires onto the plane of the PDSM and fused the nanowires forming new connections which increased conductivity. The resulting nanowires take a new configuration which can be described as wavy. The wavy silver nanowires can then the stretched without this vertical pulling. This method led to the production of a biaxially stretchable, conductive, transparent and thin material which can lead to huge applications in the field of stretchable electronics.

As of now, the applications of this material will be largely stretchable optoelectronic devices such as display and touch screens. The more interesting and new applications of this research are wearable electronics. Before any product can be put onto the market, the conductivity of this material must be studied after being repeatedly stretched and bent. This research could lead to the development of new and exciting technologies that were not previously thought possible.