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Model makes better solar cells

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Scientists have used a new model to design an optical nanocomposite made of copper, silver and gold for use in solar cell applications. Such nanocomposites, which could easily be coated onto existing solar cells made from silicon, could be optimally tuned to the solar spectrum for the first time, so enhancing the light-absorbing efficiency of these devices.

"The optical response of nanocomposites made from dielectrics (like glass) containing metal nanoparticles is fascinating and important," says lead author Justin Trice of Washington University in Saint Louis. "For example, the amazing colours in ancient glass artifacts result from the strong absorption of specific wavelengths of light thanks to the metal nanoparticles inside the glass."

This so-called plasmonic absorption has been well studied and it is now known that the type of metal, particle size, shape and concentration all affect the resulting optical properties of a material. However, until now, there was no simple way to predict the optical behaviour of nanocomposites containing several different metals.

Earlier this year, Hernando Garcia and co-workers at Southern Illinois University made an important breakthrough in this area by developing a simple and efficient model that allowed them to accurately predict the optical response of ternary nanocomposites (that is, two metals in glass). This model, published in *Phys. Rev. B*, allowed them to mix a number of different components and predict the composite's effective dielectric function. Now, the researchers have taken this work a step further and used their mixing rules to design an optimized plasmonic solar absorbing glass containing three metals.

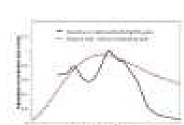

Figure 1

"One of the key steps in efficient solar energy harvesting is to absorb as much of the incident solar energy as possible," explained team leader Ramki Kalyanaraman. "Since the Sun's emission is over a large, broadband, spectrum (see red curve in figure 1), our primary objective was to design a glass that absorbs over the entire visible range (from about 350 to 800 nm)," he told *nanotechweb.org*.

The researchers achieved this by identifying metals that allow plasmonic absorption at various wavelengths

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within the visible range. They found that gold (which absorbs at around 400 nm), silver (500 nm) and copper (which has a broad absorption peak around 645 nm) fitted the bill. The team therefore decided to mix the three metals into silica glass using their computer model and optimized the concentration of each metal and their particle sizes using a simulated annealing global optimisation algorithm to achieve a broadband absorption that matches the shape of the Sun's emission curve (see black curve in figure 1).


The team

Although composites containing one or even two metals have already been made in experiments using techniques like ion implantation, the new model allows designs with any number of different metals, alloys and compounds. "We are currently making materials with three or more metals using a self-organization technique that will be guided by modelling and computations based on thin-film growth and laser processing," says team member Radhakrishna Sureshkumar "and we hope to test the optical properties of such nanocomposites within a year."

The team now plans to assemble such nanocomposites and measure their intrinsic linear and non-linear optical properties. "We also hope to develop cost-effective and simple nanomanufacturing strategies to implement these coatings in devices such as semiconductor solar cells, optical sensors and optical modulators," state the researchers.

The work was reported in *arXiv* and was recently presented at the SPIE Optics+ Photonics conference in San Diego.

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