Magic Trick with Gold and Glass

November 7 2005

Even the ancient Romans were familiar with processes for coloring glass by adding gold. Initially colorless, the glass takes on a ruby-red color when heated in a controlled fashion. The source of this color is finely divided gold clusters. The light absorption depends on the concerted oscillation of the conducting electrons in all of the gold atoms in the cluster, called plasmon oscillation.

Variation of the size, shape, or electrical properties of the particles' surroundings should influence the frequency of the oscillation and thus the color of the absorbed light. This could allow for the production of materials that are suitable for use in nanophotonic components, including tiny optoelectronic circuits or optical storage devices.

How to make this work has been questionable until now, as the chemistry of gold in glass has long been a mystery. Newly published investigations have allowed K. Rademann and M. Eichelbaum in collaboration with the German Federal Institute for Materials Research and Testing to unravel this secret a little. Their first step was to produce soda–lime–silica glasses containing gold trichloride. They irradiated these glasses for five minutes with synchrotron radiation. Synchrotron radiation is extremely energetic, high-intensity light; it is produced when electrons are strongly accelerated—they nearly reach light speed within the synchrotron—and then are deflected by a magnet.

The synchrotron radiation effected a photochemical reduction of the trivalent gold ions to elemental gold, producing an even brown tone in the irradiated areas of the glasses. These were then heated to over 550

°C for a longer time (30–45 minutes) which led to the development of the red color that is characteristic of plasmon oscillation—evidence for the aggregation of gold clusters with a radius of between 3 and 6 nm, depending on the length of the treatment and the temperature. As the size of the gold particles increases, the researchers observe a red shift of the plasmon oscillation; that is, a shift to higher wavelength regions of the spectrum.

Simple heating thus allows the control of the size of gold particles in glasses that were previously activated with light; this allows for control of the absorption wavelength of the plasmon oscillation. This is a requirement for the use of these glasses as nanoscale components of optoelectronic circuits.

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Title: On the Chemistry of Gold in Silicate Glasses: Studies on a Nonthermally Activated Growth of Gold Nanoparticles
Angewandte Chemie International Edition, doi: 10.1002/anie.200502174

Source: Angewandte Chemie