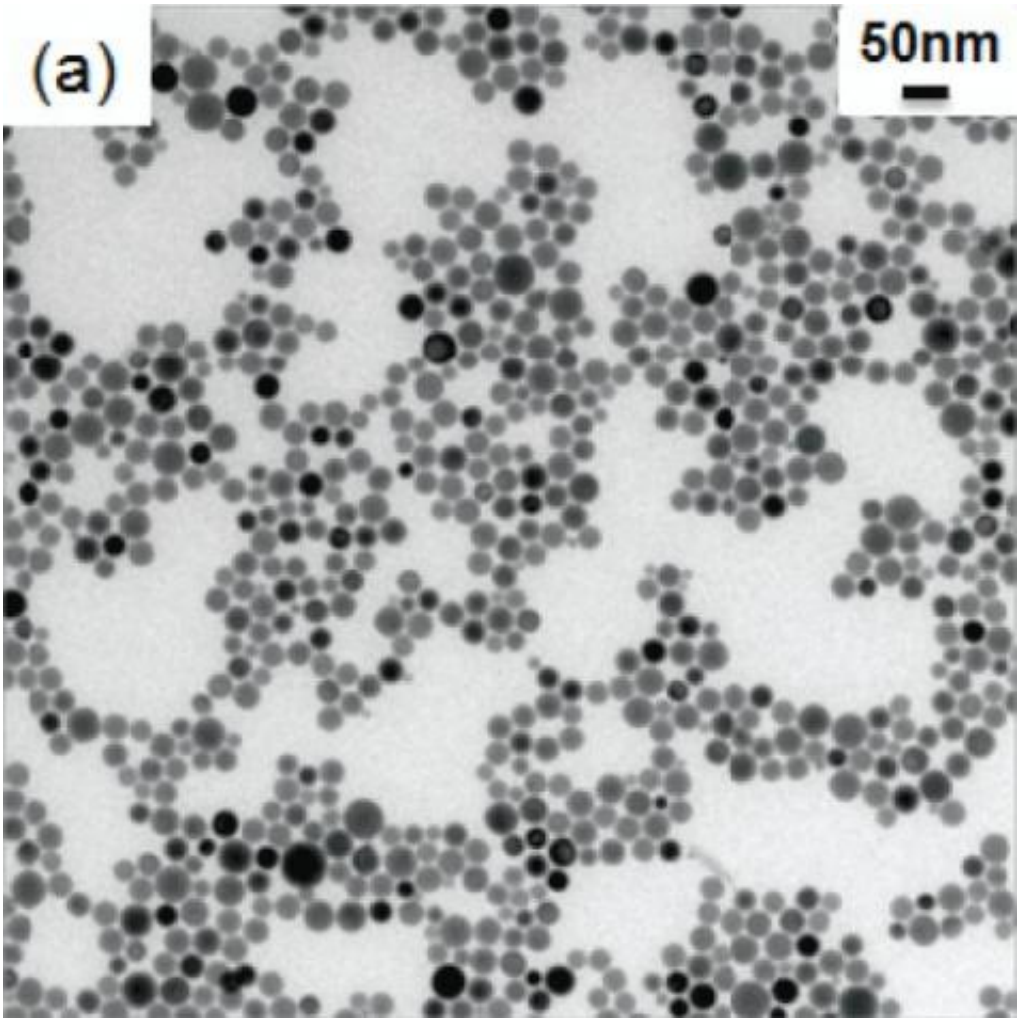
Ink with tin nanoparticles could print future circuit boards

April 12 2011, By Lisa Zyga



This image, taken with a transmission electron microscope, shows 29.1-nm nanoparticles that were used to make conductive ink. Image credit: Yun Hwan Jo, et al. ©2011 IOP Publishing Ltd.

(PhysOrg.com) -- Almost all electronic devices contain printed circuit boards, which are patterned with an intricate copper design that guides electricity to make the devices functional. In a new study, researchers have taken steps toward fabricating circuit boards with an inkjet printer. They have synthesized tin (Sn) nanoparticles and then added them to the ink to increase its conductivity, leading to an improved way to print circuit boards.

The researchers, from KAIST and the Korea Institute of Machinery and Materials, both in Daejoen, South Korea, have published their study on using tin nanoparticles in highly conductive ink in a recent issue of *Nanotechnology*.

Currently, most circuit boards are printed using multi-step methods such as conventional vacuum deposition and photolithographic patterning. However, these methods have disadvantages since they require a high processing temperature, involve toxic waste, and are expensive. Fabricating circuit boards using inkjet printing overcomes these limitations, and in comparison to the other methods is fast, simple, and inexpensive. Inkjet printing could be used for a variety of devices, such as RFID tags, LEDs, organic solar cells, organic thin-film transistors, and biomedical devices.

Recently, several studies have investigated different materials, such as polymers, carbon nanotubes, and metal nanoparticles, which could be used for the conductive ink. Although polymers and carbon nanotubes have advantages for printing on flexible displays, their conductivity is too low for them to be used for conductive ink materials. Metal nanoparticles have higher conductivity, and so are more suitable for conductive ink materials.

“The greatest significance of our work is that it is the first attempt to print conductive patterns with the Sn-containing conductive ink,”

coauthor Yun Hwan Jo of KAIST told *PhysOrg.com*. “Several papers reported the synthesis of Sn nanoparticles for interconnection materials. However, no obvious melting temperature depression was observed due to the relatively large size and low uniformity of the Sn nanoparticles. In addition, there has been no report for fabricating conductive ink with Sn nanoparticles.”

In their study, Jo and coauthors synthesized a large amount of uniformly sized tin nanoparticles. As they explained, synthesizing tin nanoparticles that have a very small size is important because it leads to a lower melting temperature compared to that of bulk tin. For instance, while bulk tin melts at 232 °C, tin nanoparticles with a diameter of 11.3 nm melt at 177 °C. A lower melting temperature is beneficial because it means lower energy consumption, less substrate warping, and fewer thermal stress problems. The researchers also applied surface treatments to the conductive ink to decrease the resistance by a factor of 20.

“Two factors, cost and low temperature, are the advantages of the Sn-containing conductive ink,” Jo said. “Ag, Cu and Au nanoparticles are widely used to fabricate conductive ink. However, Au and Ag are expensive. And the melting temperature of Ag, Cu and Au nanoparticles is higher than that of Sn nanoparticles (177.3 °C, this experiment).”

By adding the tin nanoparticles to an ink solution, the researchers printed patterns of highly conductive ink from an inkjet printer. As the first demonstration of inkjet printing with tin nanoparticles, the results show that the new technique looks promising for printing various electronic devices that require conductive patterns.

“We are under study to fabricate conductive lines with conductive Sn ink via inkjet printing for flexible OLED devices,” Jo said. “We are optimizing the jetting conditions to draw complicated patterns using conductive Sn ink.”

More information: Yun Hwan Jo, et al. "Synthesis and characterization of low temperature Sn nanoparticles for the fabrication of highly conductive ink." *Nanotechnology* 22 (2011) 225701 (8pp). DOI: 10.1088/0957-4484/22/22/225701