Team develops a microwave-assisted method for producing thin films

December 19 2012

Growth of new materials is the cornerstone of materials science - a highly inter-disciplinary field of science that touches every aspect of our lives from computers and cell phones to the clothes we wear. At the same time, the energy crisis has brought the spotlight on synthesis and growth of materials for clean energy technologies, such as solar cells and batteries. However, researchers in these areas do not simply grow materials —they assemble the atoms and molecules that form so-called thin films on various substrates. It is a process that is highly complex, time-consuming and requires significantly high temperatures.

Now a multidisciplinary team at the University of Texas at Austin's Cockrell School of Engineering is using microwave energy to assemble atoms into thin films and grow them directly onto a substrate at significantly low temperatures. Results of the team's research conducted under the supervisions of Professor Arumugam Manthiram of the Texas Materials Institute and the Department of Mechanical Engineering and Professor Ali Yilmaz of the Department of Electrical and Computer Engineering, were published in the 19th December issue of Nature Publications' online, open-access journal *Scientific Reports*.

"Lowering the temperature at which thin films of relevant materials can be grown is one of the key focus areas of our research," said Reeja Jayan, postdoctoral fellow at UT-Austin and one of the lead authors of the paper. "With our microwave process, we could bring down temperatures to the level that enable us to grow materials on heat-sensitive surfaces, such as plastics, without damaging them."

The conventional methods for growing thin films typically require temperatures over 450 degrees Celsius for several hours and a cumbersome multi-step process. With the new method, thin films can now be grown at temperatures as low as 150 degree Celsius in less than 30 minutes, in a single step process, by using microwaves.

"With this new method, the process of thin film growth is made simple, wherein a solution containing the atoms of the desired material together with the substrate when exposed to microwaves can result in controlled film growth" said Professor Manthiram who supervised the experimental work. "Applications that could utilize this process include developing thin film batteries and solar cells that could be integrated into various devices like cell phones and tablets."

The team coats a conducting layer—similar to a metal—over their substrate, which serves like an antenna to attract the microwaves. The energy from the microwaves then coerces atoms from the solution to "self-assemble" into uniform thin films on the substrate. The local heating generated by the interaction between the microwaves and the metal layer serves to fuse the thin films to the substrate. It is an interaction so powerful that it makes the films strongly adhere to the substrate.

As part of the research, a computational model of the process was developed by the team, which helps better understand the physics behind the microwave interaction phenomena and provides them with predictive guidelines that can significantly reduce the number of experiments needed for future research. The team at UT-Austin has successfully demonstrated assembly of titanium oxide thin films at low temperatures, and is currently working toward the assembly of thin films in a variety of materials.