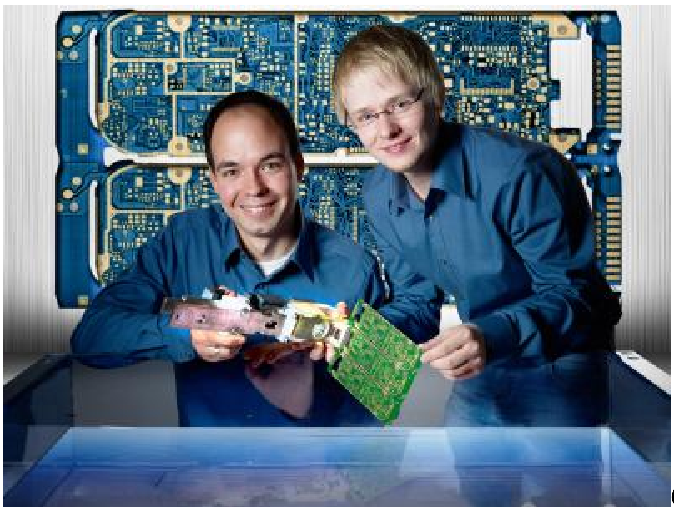
Materials Scientists Prevent Wear in Production Facilities

Printed circuit boards (PCBs) are core components in every mobile phone, television and computer. PCBs can be thought of as acting like a nervous system, forming a network that links the microchips mounted on the board and supplies them with power. One of the most important methods of fabricating large PCBs involves the precision electroplating of copper onto the PCB panel immersed in an acidic electrolyte bath. However, some of the titanium parts used in the electroplating process suffer substantial wear within a short space of time. Replacing these parts generates significant costs. A materials science research team at Saarland University has now developed a process that enables the damaged components to repair themselves while the PCB fabrication process continues. Atotech, the company responsible for manufacturing almost 90 percent of all PCBs used in mobile phones worldwide, is now saving several millions of euros each year as a result. The new process, for which a patent application has been filed, was developed jointly by the Saarbrücken research group led by Professor Mücklich and the project group from Atotech. Recently, the Steinbeis Foundation in Stuttgart has chosen to honour the team's achievements by conferring the Steinbeis Transfer Award 2012, which is bestowed annually for an outstanding example of technology transfer into the industrial sector.


Christian Selzner and Dominik Britz have developed a process that enables the damaged components to repair themselves while the PCB fabrication process continues.

Electronic components are becoming ever smaller and ever more powerful while at the same time having to be connected with one another in increasingly complex ways. "A printed circuit board today is an extremely complicated three-dimensional structure, that essentially acts like a central nervous system connecting all the various individual components," explains Professor Frank Mücklich, Professor of Functional Materials at Saarland University and Director of the Steinbeis Material

Engineering Center Saarland (MECS). The method typically used for high-precision fabrication of large-surface PCBs is acid copper electroplating, in which the PCB panel is immersed in an acidic solution of copper ions, the electrolyte. A very high electric current flows through the board transporting copper ions in the electrolyte to the surface of the PCB and into the minute holes, known as vias, into which the leads or contact pins of the electronic components will later be inserted. "As a result, the PCB is covered with a uniform extremely thin coating of copper whose thickness is less than one tenth of the diameter of a human hair," says Mücklich.

The PCB panels are held in solution by acid-resistant titanium PCB plating clamps that guide the current onto the PCB panel. "These clamps have to withstand an enormous amount of electrical energy over an area of only a few square millimetres. The extremely powerful current generates sparks that are similar to a lightning discharge and that damage the clamps by eroding their surface each time the panels undergo plating," says Mücklich, describing the fundamental problem of modern electroplating systems. The Saarbrücken material scientists examined the damage mechanisms using not only electron microscopy, but also tomographic techniques that allow imaging down to the nano- and even atomic scales. "We came to realise that with spark temperatures of around several thousands of degrees the previous strategy of trying to develop materials with ever greater resistance to these extremely hot and destructive sparks was not going to prove successful," explains Mücklich. Even the use of very expensive precious metals, such as platinum, only delays but does not stop the onset of damage. Working together with engineers from Atotech, the material scientists and technologists at Saarland University came up with an extremely economical and reliable solution. According to Mücklich: "The new process is similar to the mechanism used to regenerate human skin when wounds heal."

The damaged clamps migrate in a circular path within the production facility as if on a carousel. And, like the PCBs that they hold, a new thin layer of copper is plated onto them. "We are essentially creating a recyclable wear layer on the clamps. This has the effect of immediately repairing any damage to the clamp surface and, quite incidentally, also increases the conductivity of the clamps several-fold," says Mücklich. The new process means that there is no longer any need for the complex procedure of removing and replacing the clamps at Atotech's many production facilities. The production process can therefore continue uninterrupted. "Atotech is the market leader in this field, operating more than 600 production facilities of this type around the world. This new development will result in savings of several millions of euros each year," says graduate engineer Bernd Schmitt, who has been Atotech's coordinator on the research project. Atotech and the scientists and engineers from Saarland University have now filed jointly for a patent application.

The process was developed by materials scientist Frank Mücklich and his research assistants Dominik Britz and Christian Selzner in the space of just one year. To enable the research to be conducted, Atotech installed a purpose-built (and very heavy) test facility at the Steinbeis Research Centre that is located on the Saarbrücken campus. In the first stage of the project, the researchers used new three-dimensional imaging techniques to study what goes on inside the titanium contacts during electroplating. "We used high-resolution electron microscopy as well as nanotomography and atom-probe tomography. The images recorded with these techniques are then assembled in a computer to create a precise spatial representation – even down to the level of individual atoms," explains Professor Mücklich.

In their search for more robust materials, the research team also used laser cladding to deposit microscopic layers of different materials onto the titanium contacts. They also employed laser interference structuring techniques to modify the surface of the clamps in an effort to make them more robust. While these techniques certainly improved the properties of the original titanium, the improvements were not sufficient to permanently withstand the enormous stresses to which the clamps are subjected during the PCB electroplating process. "This led us to the idea of using copper as a sacrificial layer that can be continuously replenished during the PCB production process. The advantages of this approach are that copper is far cheaper than the other materials that had been tested and that it was already present in the system. It was this that ultimately led to the successful conclusion of the research project," explains Frank Mücklich. In recognition of their efforts, Professor Mücklich, together with research assistants Dominik Britz and Christian Selzner and the project members from Atotech, will receive the Transfer Award, which is conferred by the Steinbeis Foundation and worth up to 60,000 euros, at a ceremony in Stuttgart.

Saarland University [1]

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