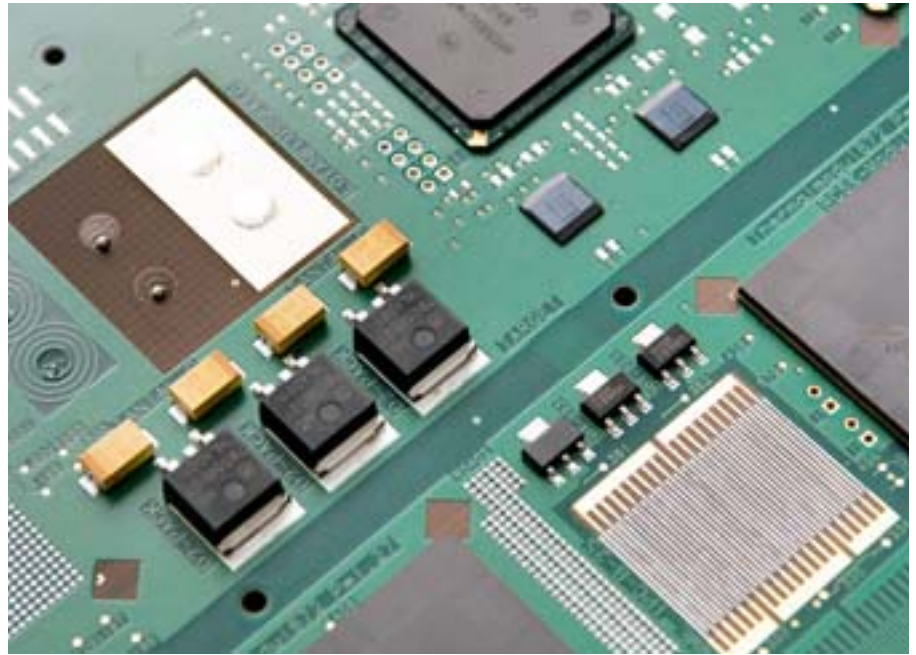


Lead-free solders join the most diverse components to circuit boards (top). The entire soldering process (pastes included) is optimized at Siemens' lab in Berlin (bottom).

Circuit boards look like miniature models of big cities. The gray conductor paths could be streets and the tower-shaped capacitors skyscrapers. The color of the board's surface is green. "But until now, circuit boards were green only in terms of their surface color," says Dr. Peter Demmer from Siemens Corporate Technology (CT). Things are changing, though, as Siemens researchers strive to make the boards green in the figurative environmental sense as well. It's an important issue, as circuit boards can be found in virtually every product containing electronic components. The boards run coffee machines, computer tomographs, electric motors, and entire power plants.

Lead — a toxic heavy metal frequently found in solders — is a substance Siemens has always tried to avoid using. In fact, the company has been more restrictive here than required by legislation. In the summer of 2006, lead was banned from use in many electrical and electronic devices by the European Union. "Over the



# Circuit Boards Go Green



Siemens researchers are making electronic components more environmentally friendly. They're eliminating lead from soldering pastes and bromine-based flame retardants from some printed circuit boards. Fujitsu Siemens Computers is already selling PCs containing "green" circuit boards worldwide.

long term, we also want to replace flame retardants that contain bromine, even though there's still no legislation on that," says Demmer, who manages the "Green Circuit Boards" project at CT. Bromine compounds are dangerous, as they can release carcinogens in the event of a fire.

That's why some of Siemens' green circuit boards already contain organophosphorous compounds, which at the moment are considered less harmful. Flame retardants prevent the spread of smoldering fires, such as those caused by short circuits.

An excellent example of active environmental protection is the "Green PC" from Fujitsu Siemens Computers (FSC). All internally produced or exclusively commissioned components in this computer are free of both lead and bromine, according to Hans-Georg Riegler-Rittner, head of Environmental Protection and Quality Management at FSC in Augsburg, Ger-

many. "The only components in the Green PC that might contain brominated flame retardants are the hard drives or the LAN or modem sticks purchased from outside," Riegler-Rittner explains. Green PCs from FSC also consume very little energy. Under ideal conditions, they require no more power than it takes to light a 60-watt bulb — and the computers are easy to recycle.

**Big Hit in Scandinavia.** "Environmentally friendly computers don't cost our key account customers any more than conventional PCs," says Riegler-Rittner. While the Green PCs are slightly more expensive to produce, they are only used commercially, which means the additional cost can be recouped in delivery logistics systems. "We no longer pack each PC individually for our major customers; instead, we deliver a complete package containing hundreds of computers," Riegler-Rittner explains.

The environmentally friendly PCs, which are shipped all over the world, are an especially big hit in Scandinavia, not least due to the fact that the new Nordic Swan environmental certificate requires adherence to very strict standards — and the Green PCs are currently the only computers to have received such certification.

FSC sold more than 1.3 million Green PCs worldwide last year — even though private customers are still unable to purchase them. "Our normal PCs can compete at retail prices because many elements are bought in from the outside. But unfortunately, those components still contain bromine," Riegler-Rittner explains.

Materials issues are also the focus of work conducted by Dr. Klaus Peter Galuschki. For years, Galuschki and his team at Siemens CT in Berlin have been assessing the quality of lead-free soldered circuit boards and optimizing the processes for manufacturing them. "Characteristics such as lifespan, stability, and electrical

properties should not be negatively affected by the change-over to lead-free solders," says Galuschki. The problem is that practically no historical data exists on the performance of new solders, most of which are alloys made of tin, silver, and copper. Soldering with lead, on the other hand, is a procedure with a long tradition — and up until just a few years ago, all manufacturing processes for electronic equipment were designed for it.

"A major problem with the conversion from lead was the high melting temperatures of the new solders, which many common electronic components were unable to withstand," explains Galuschki. The lead-free soldering materials don't melt until approximately 220 degrees Celsius, around 40 degrees higher than the melting point of conventional tin-lead solders. The advent of more heat-resistant components made the conversion possible.

**Stable Compounds.** The materials used in soldering pastes were also reviewed, as state-of-the-art soldering today no longer involves soldering irons and wire. "We buy soldering paste and press it through a molding tool onto circuit boards," says Galuschki. The pastes contain micrometer-sized globules of the selected metal alloy, fluxing agents that prevent the soldering point from oxidizing, and thixotropy agents — substances that make the mixture sticky, ensuring that the globules adhere to the boards.

Once the paste has been applied, a SIPLACE machine places components on the board surfaces. After that, the boards proceed through

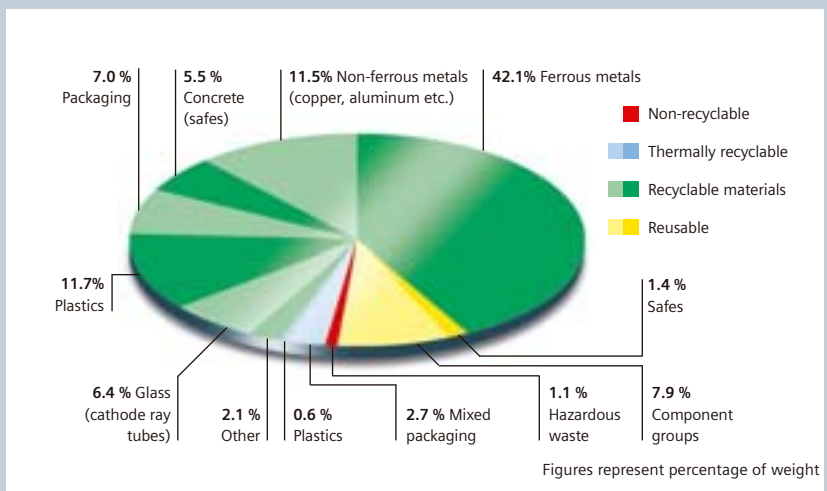
an oven, where the component contacts and soldering material melt together. "The key here is sophisticated temperature regulation to ensure that the solvents in the soldering paste are vaporized before the soldering material melts," says Galuschki. Without such vaporization, troublesome gas bubbles could develop in the contacts. Researchers carry out hardness tests and employ powerful microscopes to identify such errors, using the resulting knowledge to further optimize the production process.

Although Siemens converted to lead-free soldering pastes several months before the EU ban in 2006, Galuschki and his team still face constant challenges. "We are continually adapting the processes," he says. "One reason why we have to do so is miniaturization. We have to keep packing more functions into small boards."

More functions mean more tiny components that heat up quickly in the soldering oven. As a result, you either have to make such components more heat resistant or alter the temperature regulation accordingly.

Circuit boards are set to become even greener in the future, and in some cases will even be produced using renewable raw materials such as sugar cane or waste from the paper industry or biodiesel manufacturing processes. "Truly green circuit boards are really yellow," says Galuschki, as he points to a prototype made of a light-colored bioplastic. Although mass production of the yellow "green" circuit boards is still a long way off, the first samples from the lab have already landed on Galuschki's test stand. ■ Andrea Hoferichter

## IT Reutilization and Recycling



Source: Fujitsu Siemens Computers, 2007

Just under 99 percent of all the old IT equipment Fujitsu Siemens Computers accepts for disposal — including PCs and cash register systems — can be recycled or directly reused.