Philips Semiconductors

Leading the way

to lead-free packaging

PHILIPS

Let's make things better.

Solving the Plumbum (Pb) conundrum

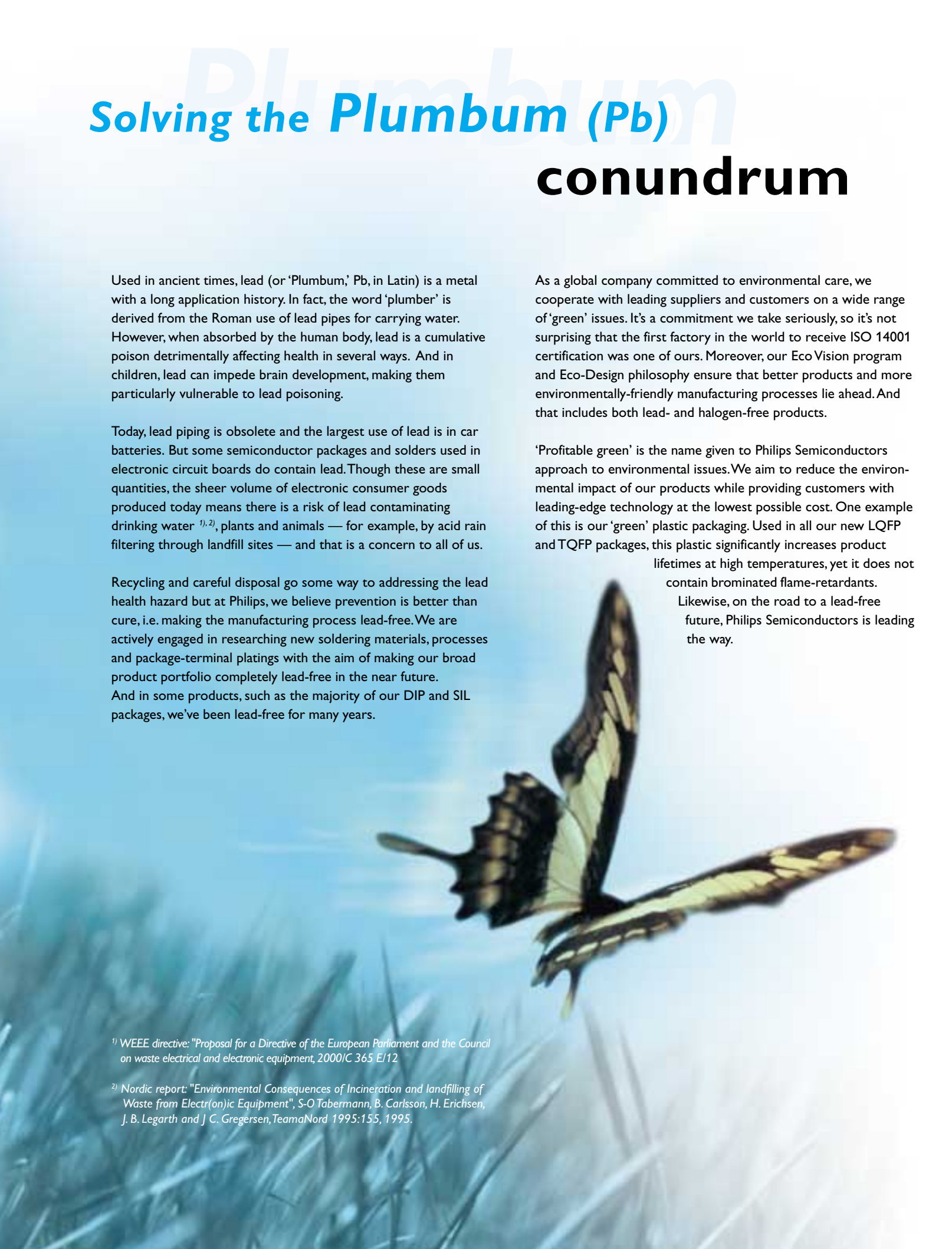
Used in ancient times, lead (or 'Plumbum,' Pb, in Latin) is a metal with a long application history. In fact, the word 'plumber' is derived from the Roman use of lead pipes for carrying water. However, when absorbed by the human body, lead is a cumulative poison detrimentally affecting health in several ways. And in children, lead can impede brain development, making them particularly vulnerable to lead poisoning.

Today, lead piping is obsolete and the largest use of lead is in car batteries. But some semiconductor packages and solders used in electronic circuit boards do contain lead. Though these are small quantities, the sheer volume of electronic consumer goods produced today means there is a risk of lead contaminating drinking water [1), 2)], plants and animals — for example, by acid rain filtering through landfill sites — and that is a concern to all of us.

Recycling and careful disposal go some way to addressing the lead health hazard but at Philips, we believe prevention is better than cure, i.e. making the manufacturing process lead-free. We are actively engaged in researching new soldering materials, processes and package-terminal platings with the aim of making our broad product portfolio completely lead-free in the near future. And in some products, such as the majority of our DIP and SIL packages, we've been lead-free for many years.

As a global company committed to environmental care, we cooperate with leading suppliers and customers on a wide range of 'green' issues. It's a commitment we take seriously, so it's not surprising that the first factory in the world to receive ISO 14001 certification was one of ours. Moreover, our Eco Vision program and Eco-Design philosophy ensure that better products and more environmentally-friendly manufacturing processes lie ahead. And that includes both lead- and halogen-free products.

'Profitable green' is the name given to Philips Semiconductors approach to environmental issues. We aim to reduce the environmental impact of our products while providing customers with leading-edge technology at the lowest possible cost. One example of this is our 'green' plastic packaging. Used in all our new LQFP and TQFP packages, this plastic significantly increases product lifetimes at high temperatures, yet it does not contain brominated flame-retardants. Likewise, on the road to a lead-free future, Philips Semiconductors is leading the way.



1) WEEE directive: "Proposal for a Directive of the European Parliament and the Council on waste electrical and electronic equipment, 2000/C 365 E/12

2) Nordic report: "Environmental Consequences of Incineration and landfilling of Waste from Electr(on)ic Equipment", S-O Tabermann, B. Carlsson, H. Erichsen, J. B. Legarth and J C. Gregersen, TeamaNord 1995:155, 1995.

The need to be lead-free

Throughout the electronics industry, the desire for lead-free electronics is a hot topic. Customers and manufacturers alike are keen to ensure that new regulations in Europe, the US and Far East are complied with, sooner rather than later:

- In Europe, a draft EU directive on Restrictions on the use of Hazardous Substances (RoHS) requires the elimination of lead in electronics, in all but special applications, by January 1st, 2006
- In Japan, electronic waste and recycling laws oblige manufacturers to eliminate or recover their waste products containing lead
- In the United States, laws banning or restricting the use of lead are already in place for many products and there is an increasing demand for a total ban.

The electronics industry is now focused on lead-free assembly processes and the issues concerning the higher temperatures needed for both reflow and wave lead-free soldering. By investing heavily in our own research organization, we are developing cost-effective lead-free manufacturing processes that ensure the reliability of our components. Moreover, we are being proactive in also looking at solutions for devices where lead is contained inside the package: replacing lead-based solders in some Multi-Chip Modules with new glues, for example.

Tackling the issues

Understanding all the potential risks of going lead-free is the key to ensuring our future success. By thoroughly addressing the following issues, we are confident that a lead-free future is just around the corner:

- Forward compatibility – ensuring that new lead-free products meet customers' requirements, offering compatibility with both lead-based and lead-free solders/PCBs
- Backward compatibility – ensuring that current products can be used with lead-free technologies
- Re-qualification of current products – updating the product portfolio with lead-free solutions that meet industrial standards
- Reliability – the ability of our devices to cope with the higher temperatures of new manufacturing/assembly processes[1] and ensuring the reliability of solder joints using new materials.

Our strategy to expand our range of lead-free packages comprises a thorough investigation to tackle all of the above issues, ensuring full compatibility with new soldering processes, and to introduce lead-free platings for the terminals and solder ball connections of all packages.

[1] Increased danger of delamination measured in Moisture Sensitivity Level (MSL) test.

Lead-free *terminals*

With many years of experience in using pure tin to coat semiconductor package leads/terminals, we know that tin is the logical choice for a drop-in replacement for those devices currently using lead-alloy coatings. We have studied whiskering with tin finishes, focussing on the leads of surface-mount devices and the results are encouraging. Extensive testing for all packages is now underway.

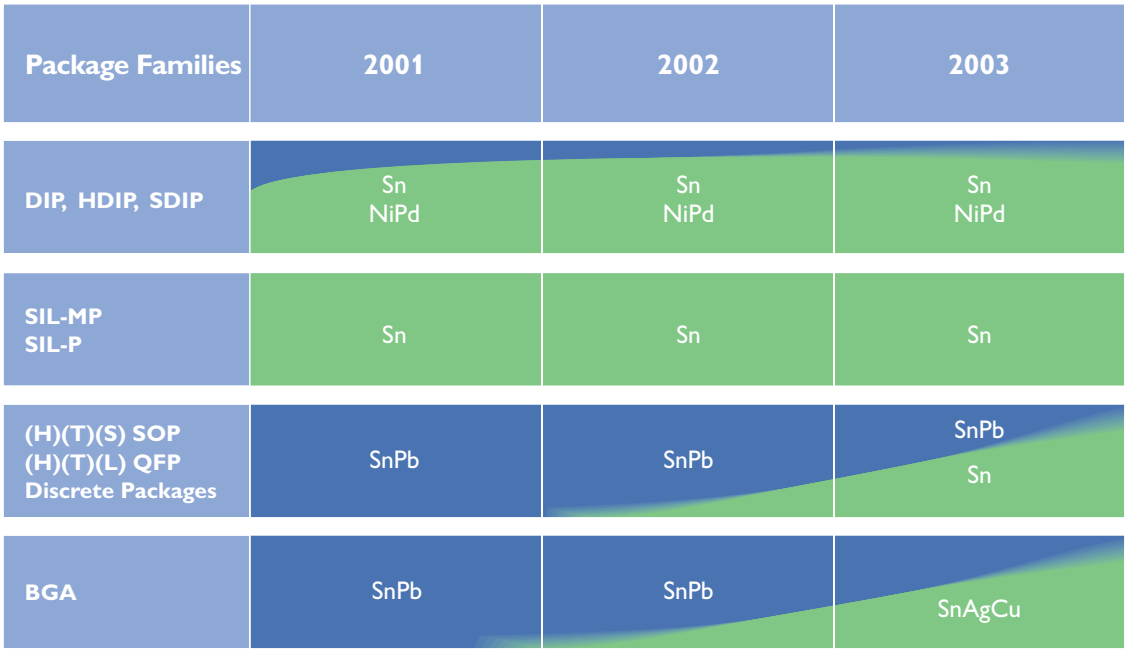
Pure tin and SAC offer a very compatible replacement for lead alloys and consequently they are our preferred solution. In exceptional circumstances when pure tin is not feasible, we will offer alternative alloys. For the contacts of ball-grid arrays (BGAs), we selected SAC alloy.

Roadmap

- Through-hole packages (e.g. DIP, SIL):
  - More than 90% are now manufactured with lead-free terminals.

- SMD packages, leadframe based (e.g. SO, QFP) and Discrete Semiconductors:
  - Process selection/evaluation: Q1-2, 2001
  - Pilot production: Q3-4, 2001
  - Volume ramp-up: 2002

- Array packages (BGA):
  - Process evaluation: Q2-3, 2001
  - Pilot production: Q4, 2001
  - Volume ramp-up: 2002

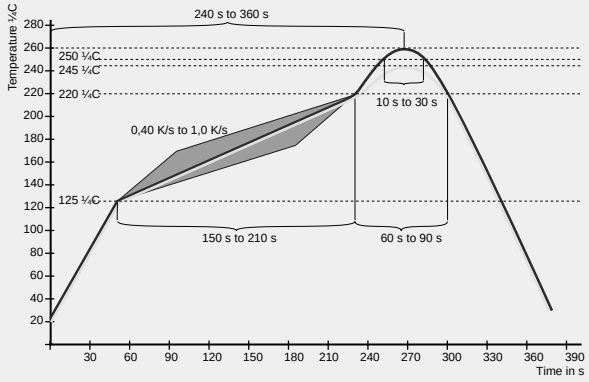


Proposed lead-free soldering process

Based on current research, we propose using SnAg3.8Cu0.7 (SAC) eutectic solder for general-purpose applications. In wave soldering, this would entail a bath temperature of 260 C and a contact time of about 3 seconds. The same SAC alloy would also be used for reflow soldering. Our temperature profile (see below) for testing products is based on experiments and proposed JEDEC specification although exact conditions are under review.

Reflow profile / flow parameters for MSL testing

	260 ¼C	245 ¼C
Ramp rate	not specified	not specified
Preheat	125 C to 220 C 150 s to 210 s 0.4 K/s to 1.0 K/s	125 C to 220 C 150 s to 210 s 0.4 K/s to 1.0 K/s
Time at T>220 C	60 s to 90 s	60 s to 90 s
Peak temperature	260 C -5/+0 C	245 C -5/+0 C
Peaktime	10 s to 30 s (250 C)	10 s to 30 s (235 C)
Cooling rate	6 K/s	6 K/s
Time from 25 C to peak	240 s to 360 s	240 s to 360 s



Our current research indicates that higher soldering temperatures affect a number of surface mount devices. It is advised to keep the package temperature at 245 C max.. Work continues to improve the resistivity of the products to high soldering temperatures. In addition, Philips Semiconductors is assessing mechanical stress and fracturing in ceramic and glass components SAC is stronger than lead-based solders.

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