New Exemption Request:

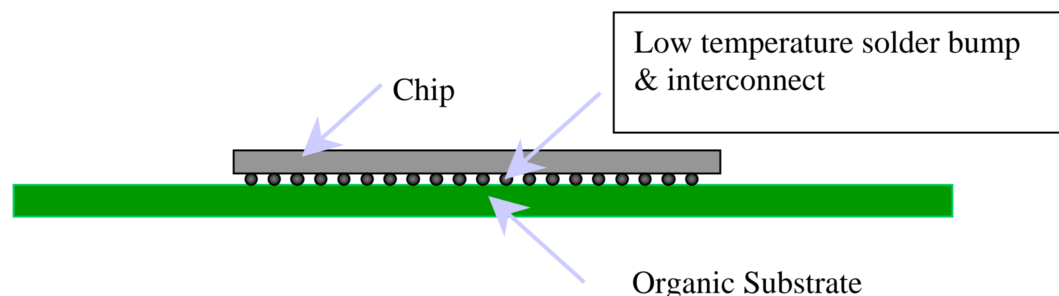
Lead-bearing solder to complete a viable electrical connection internal to certain integrated circuit packages (Flip Chips) (exemption until 2010).

Outline of the problem and substantiation of the necessity for the exemption:

Certain integrated circuit (IC) packages are currently manufactured with low temperature solder for the internal electrical connection. These IC packages are commonly referred to as "flip chip". Organic substrates require low melting temperature solder to connect the chip to the substrate. Low temperature (eutectic, lead content less than 40%) solder has been used for many years and provides a product which is suitable for many mainstream electronics applications. The amount of lead in the solder joint is less than a half compared to the high temperature lead solders which are currently exempted from the requirements of Article (4) of the RoHS directive. This exemption was granted because there are no known lead-free technical alternatives to its use in high performance/high reliability packages.
This new exemption request is for a even narrower application – lead-bearing solder required to complete a viable electrical connection internal to the integrated circuit package.

Today flip packages are used ubiquitously in computing applications, in hard disc drives, handsets and portable electronic devices (e.g. cameras, radios, personnel digital assistants (PDA's), in cars (ABS systems and engine control unit (ECU) microcontrollers.

Figure 1 Diagram of a Flip Chip Package with Internal Connection Technology



In flip chip packages, tiny amounts of tin lead solder are used to connect the chip to the substrate. These bumps (internal to the package) for state of the art flip chips are about the same size as the diameter of a human hair and may contain less than 0.002 mg lead per bump. Replacing the tin-lead solder balls (outside the package) with lead-free solder balls eliminates more than 97-99% of the lead from the finished package.
The connection between the chip and the substrate forms the heart of the integrated circuit package. After the flip chip connection is formed, the gap between the die and the substrate is filled for mechanical and environmental protection. At this point, the die can be encased in a plastic mold compound or covered with a lid, or the package can be installed directly into an electronic assembly with no further processing.

Explanation of the delay in information after the adoption of the RoHS Directive:

The industry began in the nineties to consider alternatives to tin lead solders and today entire product lines are available lead-free.
In the case of flip chips lead - free test units using several different alloys passed reliability testing at lab level but just recently field experience with these circuits has identified reliability issues not apparent during the development phase.

Flip chip interconnect is advantageous to wire bond packages because its efficient use of real estate, because the entire chip area can be used for I/O interconnection. In contrast traditional wire bond chips are limited to interconnection only at the edges. Result is smaller, lighter and faster products with improved electrical performance.

Range of producers:
Manufacturer spectrum for flip chips, divided by regions:

Region	*Market share flip chip*
Germany	<3.3%
EU	6.9%
Non-EU	>89.9%

All numbers based on list of top 30 worldwide semiconductor companies.

Market segment of flip chips in relation to other chips worldwide:

2002	about 2.8% of total packages are/may be FC
2004	about 4.6% of total packages may be FC
2006	about 6.5% of total packages may be FC

Relevance for the environment
Material balance accounting: How much heavy metal is used for the application in question? Which amounts can be expected within the scope of the RoHS Directive? (rough estimate)
3 – 5 mg lead per flip chip results in an imported lead volume to the EU:

Year	*2004*	*2005*	*2006*	*2007*
Worldwide lead in internal package bumps in kg	1086	1175	1379	1376
Lead imported to EU in package bumps in kg	**326**	**352**	**414**	**413**

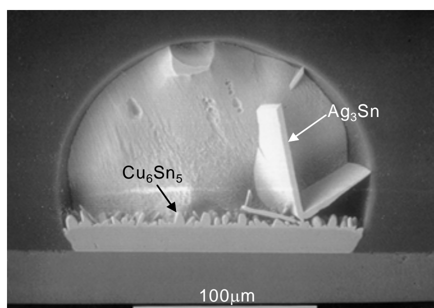
Environmental Relevance of low temperature Flip Chip Bumps:
The amount of lead in the solder joint is less than a half compared to the high temperature lead solders which are currently exempted from the requirements of Article (4) of the RoHS directive. Due to the lack of lead-free alternatives for this application, the current RoHS Directive would require manufacturers to switch to a higher lead alternative for all flip chip applications.
This request for a new exemption would allow the continued use of low lead concentration solder until lead-free alternatives are found and evaluated. It would be counterproductive for the environment to change to high-lead solders within flip chip packages in order to get coverage by the existing exemptions and the clarification to this existing exemption.

Flip chips are used in applications that serve the environment. They reduce the fuel consumption of cars by effective motor control and contribute to road safety by supporting ABS systems.

Measures taken until now by the industry to prepare for the conversion of the substance ban of the RoHS Directive
Lead-free solder research is widespread across industry, universities, institutes and national laboratories in all regions of the world. We will work with interested parties, if desired. Lead-free solder flip chip interconnections are successfully used today in many applications.
Industry believes lead-free solders can eventually be used for most flip chip applications. Our

research shows that lead-free alternatives to low temperature tin lead bumps are currently not universally available because:

1. In lead-free solutions, the formation of intermetallic alloys in this tiny bump constitute a high percentage of the joint volume and greatly reduces the resistance to impact (e.g. drop) and thermo-mechanical stresses normally found in the use environment, especially in flexible circuit applications; failure of the joint renders the integrated circuit useless;
2. Lead-free solders with a melting point sufficiently high for mainstream products are much stiffer than eutectic lead-tin solders. This stiffness increases stress on the chip, and can cause premature failure of the chip circuitry.
3. The equipments and materials required for fabricating lead-free bumps are still in the development stage. For example, fluxes for lead-free solder flip chip connections are just now being developed.
4. The industry is still learning the full impact of lead-free solder flip chip interconnect on manufacturability and reliability. For example, it is well known that lead-free solders do not wet (coat) metal terminals as well as lead-tin solders. In order to obtain adequate wetting, new fluxes are being developed. However, the nature of these fluxes impacts other assembly steps and product reliability, and the full extent of the impacts are still being determined.
5. In high temperature(high lead) flip chip solutions, attachment to the organic substrate still requires a low temperature lead-containing solder interface;



Undesirable intermetallic alloys make up a significant portion of the experimental lead-free solder bump. Current technology for the connection between the package and the PWB will not work for interconnect bumps with small dimensions.

A variety of reliability problems have surfaced and no broadly applicable reliable alternative has been identified. To ensure no disruptions in flipchip applications, it is critical to provide a new narrow exemption for low temperature lead solder for these tiny internal connections.

Time frame for finding potential substitutes:

During the next years, ITRS (International Technology Roadmap for Semiconductors) provides an industry identification/assessment of future technical challenges. Alternatives to flip chip connection may be optical interconnects or bump less area areas (direct copper to copper bonding). International chipmakers are in active development and are seeking lead-free alternatives at high speed. These solutions may find their way into products by the end of the decade, but their use will be limited to certain niche applications until the cost is reduced.