Answer to ECHA public consultation for Diboron Trioxide

Comments on the draft recommendation of substances for inclusion in Annex XIV

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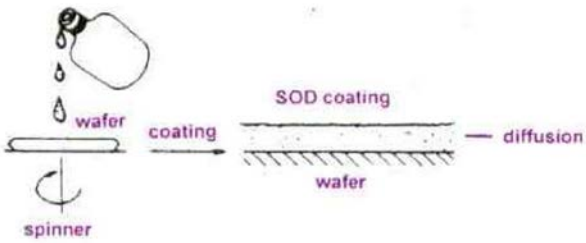
1) General comments on the recommendation to include the substance in Annex XIV

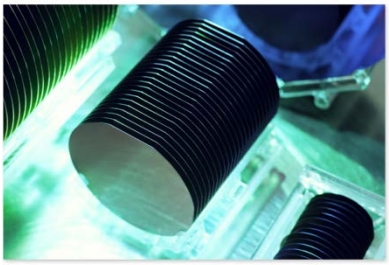
a. General context

Semiconductor manufacturing uses highly **sophisticated technologies** and relies on a **complex global supply chain** in the world. Manufacturing takes place in a **highly controlled environment**, ensuring minimization of product contamination risks and employees' exposure control. **Various chemicals** and **gases** are used in processes because of their **unique properties and functionality.**

b. Use of the substance



In **semiconductor production**, doping intentionally introduces impurities into an extremely pure (also referred to as intrinsic) semiconductor for the purpose of modulating its **electrical properties**. The impurities are dependent upon the type of semiconductor.



The chemical used is a **solution of Diboron Trioxide** in an **organic solvent**. The Boron solution is deposited on the surface of the wafer and the diffusion process occurs at a certain temperature in a **controlled atmosphere**, the Boron becoming a **dopant** of the silicon. The Boron migration takes place from the article's surface, the Boron atoms diffusing inside the Silicon wafer.

At the end of the process, the maximum Boron concentration in the silicon wafer is **inferior to 1000 ppm** and is established in average at **70-80 ppm Boron in atomic ratio in the wafer considered as the article**.

Very small quantities of the Diboron Trioxide are used to get such concentration in the **silicon die** which is the core of the component. The component itself has a volume **inferior to 0.5 cm^3** and weighs less than 2 grams. The **silicon die** has a volume **inferior to 10 mm^3** (0.01 cm^3) in most cases, e.g. **less than 1% of the volume of a standard 55 x 85 mm business card**.

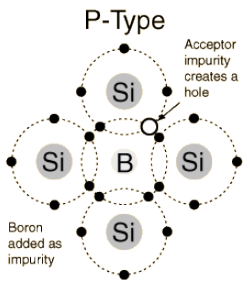
So, the **total quantity** of Boron Trioxide used by **our company in Europe** is about **8kg/year** at a concentration of 40g/l in solvent (4.2 % in weight), representing an average of **22 g/day.**

c. Diboron Trioxide doping process

The process takes place within industrial manufacture of semiconductor devices ("chips") on **silicon wafers** in fabrication areas (**fab**) called "clean rooms" in which the temperature, humidity and airborne particle contamination are strictly controlled. The Fab environment is **thousands of times**

cleaner than a hospital operating room (ECHA exposure scenarios for the semiconductor industry examples, ref ECHA-10-R-005-EN, date 5 August 2010).

STMicroelectronics employs stringent **risk management** measures and **safety procedures** to control any substance release at a manufacturing process level and reduce workers' exposure.

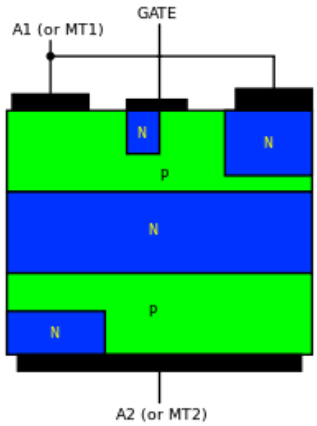


Boron is the p-type dopant of choice for silicon integrated circuit production because it diffuses at a rate that makes junction depths easily controllable. The result is an electrically conductive **p-type semiconductor**. This is a key concept in the physics of diodes and other discrete components such as **Thrystors and Triacs**.

d. About Thyristors and Triacs

Thyristors and Triacs are solid-state semiconductor devices with four layers of alternating N and P-type material. They act as **bistable switches**, conducting when their gate receives a current trigger, and continue to conduct while they are forward biased (that is, while the voltage across the device is not reversed).

Once triggered, the device continues to conduct until the gate current drops below a certain threshold, called the holding current.



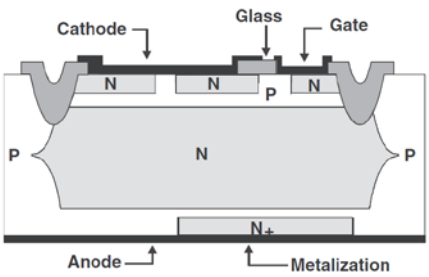
The bidirectionality makes TRIACs very convenient **switches for AC circuits**, also allowing them to control very large power flows with milliampere-scale gate currents. They often replace relays with the advantage of a **much longer life cycle**.

Low & medium power TRIACs are used in many applications such as computerized **control circuits** of many household **small and major appliances**, switching and dimming for **AC lamps**, **speed controls** for appliances with **electric motors**, switching on and off **heating** or cooking devices, **compressors**, **motors** and **valves** in "white goods"…

The **Top Glass technology** was developed 20 years ago to manufacture such products with the **high reliability required by their switching function** and in a **very cost effective way**. This is why such component manufacture can be maintained in Europe while **our competitors have their diffusion plants for similar products outside Europe**.

e. Process description uses and exposure

Diboron Trioxide is used for the manufacturing of components in **Top Glass** technology, the **most advanced and cost effective technology**, **highly reliable** thanks to its fully isolated assembly on the back side of the die and largely used for **Triacs and Thyristors** as a **proprietary technology** by STMicroelectronics in Europe (in France actually).



To manufacture **Top Glass** structures, it is of the most

importance to proceed to **ultra-deep diffusions** across the whole silicon plate, like the **"P" areas** on the component figure. To achieve such structures, our industry realizes diffusions based upon Boron atoms that permit an accurate localization in the structure. This is achieved, up to now in an industrial scale, using **Diboron Trioxide dissolved in a liquid form**.

These diffusions are processed at very high temperature (1280°) during a **10 day period or more**. The key parameter to obtain such diffusions is the **critical surface density in Boron** on the surface of the wafer before the diffusion.

A small volume of about 4 ml (0.16 g of Diboron Trioxide) of the solution is spun on the surface of each wafer. The solvent is evacuated by overheating while the Diboron Trioxide is kept on the surface of the wafer. The spent solvent is collected and sent for incineration. Industrial hygiene measurements performed in all working areas showed **that all values are within threshold limit values** (see the employee's exposure section for the actual values).

Also, **equipment design** minimizes risk to workers during normal operation and maintenance procedures are in place to prevent employees' exposure.

f. Quantity used, quantity dispersed

Previous year consumptions, since 2010 are almost aligned to the formerly given values, e.g. **8kg/year** at a concentration of 40 g/l in solvent (4.2 % in weight). **Therefore the substance is not registered for the specific use in the semiconductor manufacturing**.

In the process, further to the Diboron Trioxide deposition while dissolved in the solvent and the 5-6 hours overheating to remove the solvent, the wafers with pure Diboron Trioxide left on their surface are introduced into the furnace for high temperature diffusion. The thin layer of Diboron Trioxide provides elemental Boron for the diffusion into the silicon via the reaction:

$$2\ B_2O_3 + 3\ Si \rightarrow 4\ B + 3\ SiO_2$$

Consequently, at the end of the process, all available Boron Trioxide is **completely consumed** and **no unreacted Boron Trioxide can be found on the wafer and in the spent solvent**. Only the Boron is included into the wafer considered as **article**, the so-called **semiconductor device**, the Oxygen and the solvent molecules being released in the exhaust. In the semiconductor device, the Boron atoms are embedded into the silicon matrix and cannot be released from the article.

g. Limited number of employees involved

Only **13 people** are directly working in the area of a manufacturing line counting 150 people, in a site of 1 400 employees. One person only by shift is working on the spin-coating equipment, so that we can operate 24 hrs a day, 7 days a week. This explains that **not more than 13 different persons** are directly manipulating Diboron Trioxide dissolved in a liquid along the year. However, it should be noted that a person working on the spin coating equipment spends in average **3 hours per shift** on this station, e.g. approximately **40% of all his(her) time** while also affected to other tasks during the shift. By precaution pregnant female employees are **not authorized to access to the work station** as soon as their pregnancy is known by the labour doctor. All operators follow a **specific training program** for **process and safety rules**, they are regularly **certified** on a **3 years pace**.

h. Employees' exposure

The Industrial hygiene measurements performed **in all working areas** show all values below **0.0443mg/m3** while applicable TLV (threshold limit value) is **10mg/m3**.

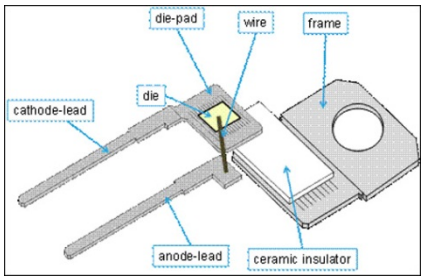
The here below table reports the relevant descriptor as per Appendix R.12.1 to R.12.6 of the ECHA Guidance on Use Descriptor System (R12) and based on the ECHA-10-R-005-EN publication EXPOSURE SCENARIOS FOR THE SEMICONDUCTOR INDUSTRY EXAMPLES – August 2010

Sector of use (SU)	SU 3	Industrial manufacturing
	SU 16	Manufacturing of computer, electronic and optical product, electrical equipment
Chemical product category (PC)	PC 33	Semi-conductor
	PC 15	Non-metal-surface treatment products
Process category (PROC)	PROC 2	Use in closed, continuous process with occasional controlled exposure (e.g. sampling) - Industrial setting ;
	PROC 13	Treatment of articles by dipping and pouring
Article category (AC)		Not applicable
Environmental release category	ERC 4	Industrial use of processing aids in processes and products, not becoming part of articles

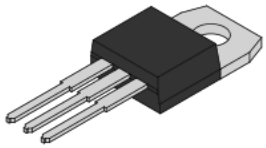
i. Absence of substance in article

No Boron Trioxide substance is available in the finished article as only Boron diffuses into the silicon. In the semiconductor device, Boron is embedded into the silicon matrix therefore no Boron can be released from the article. **Only a very small amount of dopant is required**. Weakly doped silicon crystals contain only 1 impurity per 1,000,000,000 silicon atoms, highly doped semiconductors for contain 1 foreign atom per 1,000 silicon atoms, that is to say **0.1% maximum** Boron (1000 ppm) in the silicon die.

j. Absence of consumer's exposure



There is strictly no exposure of the consumer, while **no more Diboron Trioxide** is still present in the assembled component. Only Boron can be found at a concentration **< 1000 ppm** level in the silicon part of the component (the die), this silicon part being assembled inside a **package** which is sealed with an epoxy compound (see figure besides). Such component is then soldered on the printed circuit boards of the electronics of final appliances. Even Boron is fully embedded into the silicon material, which



is not accessible to the consumer for obvious reason of electrical safety. Therefore no **consumer exposure is possible.**

k. Non applicability of the wide dispersive criteria

The wide dispersive criteria **cannot apply** to Diboron Trioxide used as dopant for semiconductors because:

1. Total quantity of substance used is **below 10 kg/year**, e.g. 0.0001 % (1 ppm) of total quantity put on the market according to the ECHA document "Draft background document for Diboron trioxide" of Sept 2014
2. The substance is used **in one site** only involving **13 different workers** in average over the year
3. The substance is not present in **products** or **articles** available to the public.

l. Adequate control of the risk during the substance's lifecycle

Referring to:

- the **risk mitigation measures** implemented during the manufacturing process,
- the absence of substance in the **product** or **article**,
- the absence of possible exposure of **consumers**,
- the non-applicability of the **wide dispersive criteria**,

it is believed that the risk is **adequately managed** during the complete substance's lifecycle: the risks related to the use of Diboron Trioxide in the **manufacturing process are adequately controlled**, ensuring environmental release control, manufacturing employees are **adequately protected** and article users are not **exposed to the substance**.

Moreover electric and electronic equipment at their end of life are managed according to the WEEE Directive requirements.

m. Strategic consequences of inclusion in Annex XIV for EU Thyristors & Triacs

Semiconductors are the **building blocks** of most all **consumer electronics**, including PCs, mobile phones, MP3 players, etc. However, this industry features a number of **distinct characteristics** that position it uniquely in the global competitive arena. These include:

1. The role of the industry as **technology enabler**, while the semiconductor industry is widely recognized as a key driver for the whole electronics value chain,
2. Continuous growth but in a **cyclical pattern** with high volatility,
3. The need for high degrees of **flexibility** and **innovation** in order to constantly adjust to the rapid pace of change in the market.

As a consequence, **changes** in the semiconductor market not only occur extremely rapidly but also anticipate changes in related industries which evolve at a slower pace. Yet another consequence of this rapid pace is that **established market strongholds can be displaced very quickly**.

The semiconductor industry generates over **5 times** its revenues in **electronics systems business** and about **20 times** its revenues in **services**, representing close to **10% of world GDP**. This correlation to the **global economy** and its own business cycles is a main driver for **semiconductor cyclicality**.

The semiconductor industry's operating costs and **capital expenditures** are **uniquely high** because new manufacturing plants, or fabs, can cost them up to 25% of annual revenues, or as much as $3-5B. Large capital expenditures are a continuous **pain point** for this industry because advances in technology require **expensive machinery**.

Also, compared to every other industry, the semiconductor industry is perennially one major factor of economy growth and every year, chip makers and designers dramatically increase the **performance of their products** while **decreasing prices**, making high-end technology goods increasingly productive and affordable for **consumers**. This constant trend for price decrease obliges semiconductor manufacturer to **yearly cost effectiveness improvements**, **prioritizing R&D which maintain competitiveness** through the required **time to market** and **avoiding unnecessary expenses**.

As already stated, the manufacture of **Thyristors and Triacs** made with the **Top Glass technology** can be maintained in EU **as long as their costs can keep competitive in front of similar products manufactured in other places of the world**, specifically Asia. This is why the best approach would be an **exemption from authorization** justified by **low volumes and absence of the criteria of wide dispersive use**, the used quantities (8 kg/year) representing **less than 0.0001 % (1 ppm) of the total quantity put on the market**, according to the ECHA document "Draft background document for Diboron trioxide" of Sept 2014 (e.g. 1,000 – 10,000 t/year). Such an exemption from authorization would be **highly justified** with respect to **the economic risks incurred by the elimination of the substance**.

2) Transitional arrangements Comments on the proposed dates

Although it is believed that the use of Diboron Trioxide in the Semiconductor sector should benefit of an **exemption from authorization** due to the **low volume usage** and the inapplicability of the **wide dispersive criteria**, being this option currently unavailable in the regulation text, here are **the arrangements that are requested by our company**:

1) To have the **latest application date after 48 months the Annex XIV publications date, instead of the actual proposal of 24 months,** this option request being supported by the fact that the substance was not registered for the intended use and that our company needs time to develop the relevant dossier.
2) To **be given a 7 years authorization review period**, this option request being supported by the fact that there is no current industrial substitution available since other boron sources are not as efficient as the one currently used.

3) Uses (or categories of uses) exempted from the authorisation requirement

Applicability of art 58.2 criteria

Use of Diboron Trioxide in the semiconductor sector in Europe is subject to the following EU wide regulation

EU. Indicative Exposure Limit Values in Directives 91/322/EEC, 2000/39/EC, 2006/15/EC, 2009/161/EU, thru OJ (L 338) 87, 17 Dec 2009)

EU. Directive 98/24/EC on the protection of workers from the risks related to chemical agents, Art. 2(b)(i), OJ (L 131) 11, 5 May 1998 (updated thru table 3.2 of Annex VI to CLP, 3 Oct 2013)

EU. Directive 92/85/EEC on pregnant workers and workers who have recently given birth or are breastfeeding, O.J. (L 348) 1, 28 Nov 1992 (updated thru table 3.2 of Annex VI to CLP, 3 Oct 2013)

EU. Directive 94/33/EC on young people at work, OJ (L 216) 12, 20 Aug 1994, as amended by Directive 2007/30/EC, OJ (L 165) 21, 27 Jun 2007 (updated thru table 3.2 of Annex VI to CLP, 3 Oct 2013).

Tours Site holds a valid authorization from Prefecture : “ARRETE PREFECTORAL N°18938 Bis du 11 Mars 2011 modifié”