



## Gases for the photovoltaic and solar cell industry

**Electronic gases play a key role in photovoltaic cell manufacturing. Our Electronics Business Area and subsidiaries Nippon Sanso and Eco-Snow™ Systems are trusted partners and suppliers in this field the world over.**

### Recycling and replacing harmful gases

Linde's activities here involve providing innovative solutions to replace harmful gases with climate-neutral ones and enable further expansion of the eco-friendly solar cell industry. High-purity gases from Linde are also often an environmentally friendly alternative to conventional materials used in the manufacture of electronic components.

Until now, the consumption of traditional electronic gases for manufacturing semiconductors and solar cells has had its downside – the conventional cleaning gases sulphur hexafluoride (SF<sub>6</sub>) and nitrogen trifluoride (NF<sub>3</sub>) are harmful to the climate. An NF<sub>3</sub> molecule has a global warming potential around 11,000 times greater than that of a carbon dioxide molecule, and an SF<sub>6</sub> molecule 22,000 times greater. Even the most stringent procedures during production cannot prevent NF<sub>3</sub>, for example, escaping into the atmosphere. Our Electronics Business Area has calculated that the small amounts of NF<sub>3</sub> released in this way add an extra two years to the period a solar cell needs to be in operation before it offsets the CO<sub>2</sub> footprint created during its production. The solar cell industry estimates an average payback period of four years, without taking NF<sub>3</sub> emissions into account, and aims to reduce this to one year in the future. Which is yet another reason to fluorine (F<sub>2</sub>), the actual active cleaning agent. Further information on our SF<sub>6</sub> recycling process as well as our award-winning on-site fluorine generator is available under Corporate Responsibility at [linde.com](http://linde.com).

### Cleaning electronic components with CO<sub>2</sub> snow

Carbon dioxide (CO<sub>2</sub>) is also being increasingly deployed in the electronics industry thanks to its valuable properties. Here, CO<sub>2</sub> snow is used in a number of applications including the removal of unwanted residue such as flux (additives that facilitate thermal treatment or handling thermally treated materials).

CO<sub>2</sub> snow is created by initially storing liquid CO<sub>2</sub> in what are usually vacuum insulated tanks at -20°C and a pressure of 20 bar. Fine snow is produced as the CO<sub>2</sub> becomes solid. And since the CO<sub>2</sub> snow sublimates (turns directly into a gas without becoming liquid) when it comes into contact with heat, it does not leave behind any residue after cleaning. CO<sub>2</sub> also has a low level of reactivity so there is no risk of chemical reactions with the environment.

Furthermore, the CO<sub>2</sub> that we industrially manufacture does not contribute to global warming as it is a by-product of combustion and the chemical processes required to make substances such as ammonia, alcohol and fertiliser. The CO<sub>2</sub> we capture in this way and turn into a valuable product would otherwise be released directly into the atmosphere.

Our subsidiary Eco-Snow™ Systems has also launched another CO<sub>2</sub> snow cleaning process that removes unwanted particles from image sensors used, for example, in mobile phone cameras or computers.

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