# Tohoku Univ. Technology

# Cryogenic cooling without helium gas

Can be used for superconducting refrigerant, cell freezing, and semiconductor cleaning

### Overview

Helium is difficult to obtain and expensive, so cooling systems that use helium are expected to be difficult to continue using. The invention enables rapid cooling without helium by continuously spraying a two-phase flow of cryogenic gaseous N<sub>2</sub> and solid N<sub>2</sub> (SN<sub>2</sub>). Specifically, it is characterized by continuously generating slush N<sub>2</sub> by spraying at transonic speed using a Laval nozzle.

In an example of cell freezing, a 23% improvement in cell survival rate during thawing was achieved compared to liquid nitrogen immersion. This invention has the potential for application in various cooling systems beyond this specific example. Additionally, its application for resist removal in semiconductor cleaning without harmful chemicals is also under consideration.

## **Product Application**

- Superconducting refrigerant
- Semiconductor refrigerant
- Rapid freezing of food and cells
- Semiconductor cleaning (resist removing)

#### **IP** Data

P No.	:	JP4961551, JP5419000, JP6153110, JP6573363
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Admin No.	:	T06-011, T07-149, T13-005, T14-156



Schematic of experimental apparatus





Geometry of Laval nozzle for  $SN_2$  particle production

# Cooling characteristics by SN<sub>2</sub> particulate spray



Irradiation time and the impact wall heat flux of solid nitrogen particulate spray

### **Related Works**

TEION KOGAKU (J. Cryo. Soc. Jpn.) Vol.42 No.5 (2007)
TEION KOGAKU (J. Cryo. Soc. Jpn.) Vol.44 No.2 (2009)
Jun Ishimoto et al 2014 ECS J. Solid State Sci. Technol.
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