APP6-1

Deign of a high temperature superconducting magnet for a single silicon crystal growth system

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Nowadays, the Czochralski (Cz) technology is widely used as a single silicon crystal growth method. This method uses a crucible to hold the melt from which the crystal is grown. In order to improve the quality of the crystals, the static magnetic fields of external magnets around the crucible are used. There are three types of magnetic field used in the Cz method: horizontal magnetic field, vertical magnetic field and cusp magnetic field. The cusp magnetic field, in which the free surface of the melt is centered between two opposite fields generated by two magnets, can adopt the advantages of both horizontal and vertical magnetic. However, the Cz method needs a strong magnetic field, that causes a very big size of the system in case of using the conventional magnet. Hence, the superconducting magnet technique can be one of attractive alternatives to optimize the dimensions and energy consumption in a crystal growth system. In this paper, the author designed a high temperature superconducting (HTS) magnet for a small-scale silicon crystal growth system and analyzed the temperature and flow distributions of the silicon melt with the cusp magnetic field. An HTS magnet for silicon crystal growth system was designed using 2G HTS wire. The metal insulation method using stainless steel tape was applied for quench protection and improving thermal conduction, and then the characteristic analysis of the magnet was conducted by the finite element method (FEM) program. Also, the 2D and 3D FEM models were built in order to consider the effect of the magnetic field on the temperature and flow distributions in the silicon melt. The simulation results showed that the melt flow was significantly suppressed by Lorentz force and the temperature distribution was uniform in the silicon melt. The fundamental design specifications and the data obtained from this study can be applied to the development of a real silicon crystal growth system.

Keywords: Silicon crystal growth, Cusp magnetic field, High temperature superconducting, Superconducting magnet

APP6-2

Development of a low temperature superconducting magnet with MgB_2 wire for a 10 kW DC induction furnace

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Generally, Nb_3SN and NbTi wires are used widely in superconducting applications and have low critical temperature (Tc of Nb3SN=18 K, Tc of NbTi=9.8 K). To maintain the low-temperature condition, liquid helium is required continuously for cooling the wire and this causes lots of maintenance cost. However, MgB2 wire has higher critical temperature than Nb_3SN and NbTi wires as 39 K and is able to make under the critical temperature condition using conduction cooling system. Therefore, if we adopt MgB2 wire to superconducting applications, we get advantages such as operating temperature, price, and cryogen free cooling system.
In this paper, the authors develop a low temperature superconducting (LTS) magnet with MgB2 magnet for a 10 kW superconducting induction heater.

First, MgB2 magnet is designed and analyzed using finite elements method for a 10 kW superconducting induction heater. Second, the magnet is fabricated using dry-winding method. Finally, MgB2 magnet is assembled to evaluate its performance and characteristics. As a result, the low temperature as 20 K, which is the operating temperature of the MgB2 magnet, can be achieved by a conduction cooling system. This study will be effectively utilized for a 300 kW superconducting induction heater and other superconducting magnet applications.

Keywords: Superconducting induction heating, MgB2 magnet, Conduction cooling

APP6-3

Analysis of a Superconducting Inductive Pulsed Power Supply for Electromagnetic Railguns

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The pulsed power supplies used in the electromagnetic railgun system should possess the capabilities of storing MJ-level energy, generating MA-level current, and delivering GW-level energy. Compared with the conventional capacitive pulsed power supplies, the inductive pulsed power supplies have become an attractive option with the major strength in energy storage density. However, great coil energy loss and short energy storage duration are two weaknesses that severely restrict their practical application and further development. Superconductivity is a promising solution to these problems. This paper focuses on the foresight of this solution, namely the theoretical feasibility of the application of the superconducting technology in the electromagnetic launch technology. First, a brief review of the inductive pulsed power supplies with superconducting magnetic energy storage (SMES) and high-temperature superconducting (HTS) coils is presented. Then, on the basis of our previous fundamental research, a technical scheme of a superconducting inductive pulsed power supply is proposed. Afterwards, a detailed analysis on its working process concerning electric-, magnetic-, and thermo-fields is conducted. Finally, the key technical obstacles in designing the superconducting coils and the overall module are further discussed, and the corresponding suggestions are concluded.

Keywords: electromagnetic railgun, inductive pulsed power supply, superconducting magnetic energy storage, high-temperature superconducting

APP6-4

Study on the basic design of multiple HTS magnets for single-sided compact MRI device

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Magnetic resonance imaging (MRI) is a useful tool for evaluating disease activity. In general, the conventional whole-body MRI devices are needed the large space and high operating cost. The whole-body MRI device has the act of over performance in order to image and diagnose parts of body such as eyes, ears, teeth and skin. Therefore, we proposed the single-sided compact MRI device which can image parts of body simply. In single-sided magnetic resonance technique, the magnets are placed on one side of the target. Thus, we have been developing the HTS magnet for single-sided compact MRI device. In this application, the required strength and homogeneity of magnetic field at upper 50 mm of the HTS magnets in the proposed single-sided compact MRI device are 0.2 T and 100 ppm/cm^3, respectively. In this study, we have designed the basic shape of MRI magnet wound with GdBCO tape wires, and racetrack HTS magnets stacked with double-pancake coils are adopted. Multiple racetrack HTS magnets were arranged in the longitudinal direction to obtain the magnetic field strength and homogeneity in the measuring space. Moreover, we have improved the homogeneity of magnetic field by placing the magnetic substance around the HTS magnets. Therefore, the electromagnetic analysis based on finite element method (FEM) was curried out to design the basic shape of HTS magnets and optimize a shape of multiple HTS magnets for single-sided compact MRI device will be presented.

Keywords: superconducting magnet, single-sided MRI