論文 / 著書情報
Article / Book Information

題目(和文)	ハイブリッド直流スイッチのアークレス開閉を実現する電気接点物理の研究
Title(English)	Study on Electric Contact Phenomena in Hybrid DC Switches with Arc-less Commutation
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Category(English)	Doctoral Thesis
種別(和文)	論文要旨
Type(English)	Summary

（博士課程）
Doctoral Program

論 文 要 旨

THESIS SUMMARY

系・コース： Department of, Graduate major in	電気電子 電気電子	系 コース	申請学位（専攻分野）： Academic Degree Requested	博士 Doctor of	（ 工学 ）
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要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

In this research, a hybrid DC switch was proposed based on the SiC-MOSFET and the Zero Voltage Switching (ZVS). It was found that arc-less current commutation was realized when current is smaller than a certain threshold value, and investigations were carried out to improve the threshold current.

In chapter 1, it was stated that with the rapid development of DC power systems, conventional mechanical and semiconductor DC switches can't satisfy requirements. Hybrid DC switching technologies, especially those with arc-less current commutations, greatly increase the reliability of DC switches, and also reduce the on-state energy losses. To realize arc-less commutation, it is necessary to study kinds of electric contact phenomena in hybrid DC switches.

In chapter 2, through the literature reviews of the other researches, we determined to develop a hybrid DC switch by using the ZVS topology and SiC-MOSFET as the power device. In addition, this research also studied materials, and the electric, thermal, solid mechanics, microfluid fields to improve the performance of the proposed hybrid DC switch, based on the related findings in other previous studies.

In chapter 3, the experimental system, including experiment circuits, contacts, and measurement equipment, was introduced. Moreover, experiment methods of different experiments were also described in this chapter.

In chapter 4, to determine and improve the threshold current for arc-less commutation by using copper contacts, the effects of some parameters including the contact diameter (10 mm, 15 mm, and 20 mm), separation speed (0.05-0.3 m/s), cable inductance in the current commutation path (0.1 μH and 0.25 μH), contact system structure (bridge type and single pole), and contact materials (copper and tungsten) on the threshold current of arc-less commutation were investigated. Through the experiment results, it was known that slow separation speed, short current commutation cables, large size of contacts, contact materials with large boiling voltage, and multi-pole contact systems are beneficial to the improvement of the threshold current of arc-less commutations. Based on the above conclusions, by using 20-mm-diameter copper contacts, setting the separation speed as 0.052 m/s, and utilizing the short current commutation cable, the threshold current of arc-less commutation is improved to 200 A, and the contact resistance is kept as low as only 0.16 mΩ.

In chapter 5, in order to further improve the performance of the hybrid DC switch, copper-tungsten clad contacts were designed by brazing a tungsten top layer on a copper bulk to achieve large contact voltage and small contact resistance at the same time, and their behaviors were evaluated by comparing with pure copper and tungsten contacts. The results showed that the new-type Cu-W clad contacts have a low on-state contact resistance 0.6 mΩ when conducting 400 A, which is almost as low as the one of copper contacts. As for the current commutation characteristics, the Cu-W clad contacts are able to commutate 600 A current into SiC-MOSFET without any arc generation, but for the copper contacts and the tungsten contacts, their arc-less current commutation ability are only 120 A and 200 A, respectively. It was also found a thinner tungsten layer and a larger the contact size are both beneficial to the performance of the Cu-W clad contacts.

In chapter 6, a 2D symmetric model of molten bridge was established by coupling the mechanical, electrical, thermal, and fluidic physics in COMSOL software. The electrical contact phenomenon in stationary contact, contact force releasing, and phase change stages with a 30 V/120 A main circuit power load were calculated. In addition, comparisons among the simulations with different current values (120 A or 60 A), and different separation speeds (0.05m/s, 0.1 m/s, and 0.5 m/s) were made. The results of the simulation showed that a large current and a quick separation speed can both break the thermal equilibrium between the contact area and the bulk of contacts, and the make heat concentrated more on the contact area, and heat it up quickly. As the sequence, contact voltage rises up continuously, and the molten bridge can also stay in liquid state stably. The results coincide with some literatures, and are useful for us to understand the softening and melting phenomenon of electric contact.

In chapter 7, summaries of this research were made.

In conclusion, in this research we finally established a hybrid DC switch that has only 0.6 mΩ on-state contact resistance when conducting over 400-A current, and it is able to commutate over 600 A without any arc generation, which is the first time in the world.

備考 ： 論文要旨は、和文 2000 字と英文 300 語を 1 部ずつ提出するか、もしくは英文 800 語を 1 部提出してください。

Note : Thesis Summary should be submitted in either a copy of 2000 Japanese Characters and 300 Words (English) or 1copy of 800 Words (English).

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