様　式　Ｃ－１９、Ｆ－１９、Ｚ－１９　（共通）

科学研究費助成事業　　研究成果報告書

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課題番号：　２６７９００６８

研究課題名（和文）陽電子発生用超伝導加速器の電子銃開発

研究課題名（英文）Development of a electron gun for a surpeconducting accelerator based positron source

研究代表者

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交付決定額（研究期間全体）：（直接経費）　　3,200,000円

研究成果の概要（和文）：500MHz同軸空洞をLLNLのSuperfishコードで設計をして、無酸素銅から空洞を制作しました。産総研が開発をしていたカーボンナノ構造電界放出型電子カソードを空洞に設置して、超伝導加速器のためのRF同軸空洞型電子銃の開発を進めている。制作した空洞の電子放出特性を測定しました。現在、電子のパルス構造を評価している。今年度開発した電子銃を超伝導加速器に接続する予定です。

研究成果の概要（英文）：We have designed and manufactured a 500 MHz coaxial RF electron gun based on extensive simulations with LLNL superfish program. The cavity was used in conjunction with a carbon nanostructured field emitter cathode in an attempt to develop an RF electron gun for an superconducting accelerator. We measured the electron current as a function of RF power. We are now characterizing the pulse structure of the emitted electrons and will connect the RF electron gun to the SCA in the near future.

研究分野：　陽電子発生、陽電子消滅、加速器

キーワード：　RF電子銃　超伝導加速器　カーボンナノ構造

１．研究開始当初の背景

Slow positrons are a unique tool for the investigation of defects in the near surface regions of a wide range of materials. Using an intense slow positron beam generated by an electron accelerator (LINAC) our group has been a world leader in positron based materials characterization for more than 20 years. We are currently developing a dedicated superconducting accelerator (SCA) for slow positron production. In order for the SCA to efficiently accelerate electrons, the electron beam should be bunched into extremely short pulses with a suitable pulse frequency (fc/n, where fc is the cavity frequency and n an integer) and sufficiency high energy (> several 100 keV). Typically either a photocathode, or a pulsed thermal electron gun with a buncher are used, with the gun either floated to extremely high DC voltages or used in combination with one or more pre-acceleration cavities. In contrast to the high cost and complexity of this system we plan to use a field-emission type electron gun in combination with a RF pre-accelerator (booster) cavity.

２．研究の目的

With this proposal we will design and construct a tunable RF gun with a fundamental frequency of 500 MHz for use with the AIST SCA. A combination of the RF gun and the existing 1/2-wave booster cavity will be used as an injector for the AIST SCA. With this set-up we aim to demonstrate high current, efficient, electron acceleration.

３．研究の方法

This project involves developing a new RF electron gun for the AIST superconducting accelerator (SCA). We plan to design, construct and test a tunable RF gun (frequency 500 MHz, i.e. the same as the SCA) based on field emission from a coniferous carbon nano-structured (CCNS) cathode. This gun will be used in conjunction with an already existing 1/2 wave, coaxial, double gap cavity which will further accelerate and bunch the electron pulses. As part of the design process extensive simulations will be performed. An RF power source will be developed based on existing 1 kW solid state amplifiers. A feedback system will be developed to control the cavity frequency in real time. The emission characteristics of the RF gun will be extensively characterized and the effects of cathode conditioning investigated. The RF gun and RF booster will be connected to the SCA and high-current electron acceleration demonstrated.

４．研究成果

1. *Simulation and design of RF electron gun.*
We performed simulations of the RF gun using the LLNL software packages (Superfish, Parmela). An example of the simulation result is shown in figure 1.

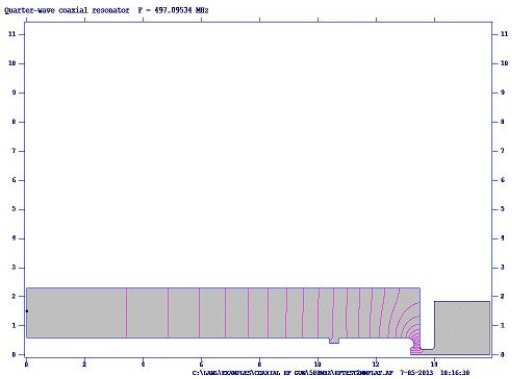
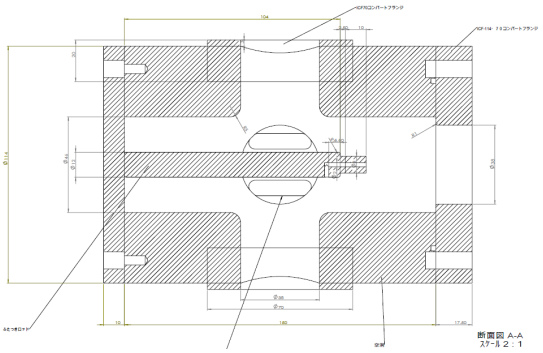
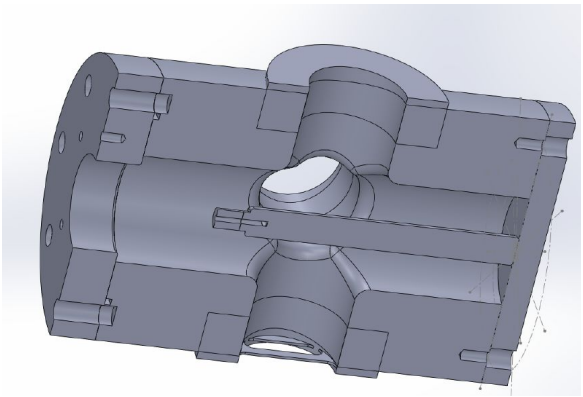


Figure 1. Simulation of the cavity in Superfish

2. *Construction and RF electron gun*
Based on these simulations we designed a cavity for the electron gun. The gun was designed in collaboration with the TIME Co. who also performed the manufacture of the cavity from a block of high purity oxygen free copper. A design drawing and photograph of the cavity is shown in figure 2.





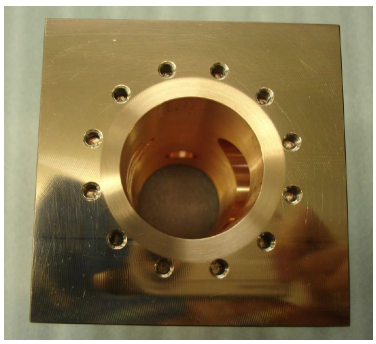


Figure 2. Design drawings and a photograph of the cavity

3. *Cathode conditioning and RF gun characterization*

After receiving all the required parts we assembled the system and performed the following series of experiments.

a) Leak check and pump down to ultra-high vacuum

b) Measurement of the RF characteristics (resonant frequency, Q)

c) Testing of electron emission under DC high electric field conditions.

d) Characterization of the electron emission with application of RF power.

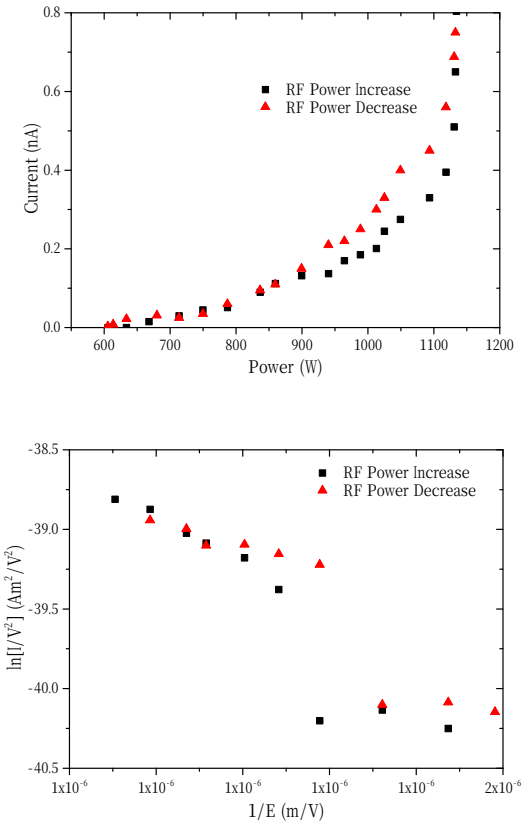


Figure 3. Electron current vs RF power for the test cavity. The lower graph shows the results converted to the standard Fowler-Nordheim formalism.

Results of the RF characterization are shown in figure 3. For the RF characterization we have not yet observed emission of short (<1ns) pulses so we have not connected the electron gun to the superconducting accelerator as planned yet. We are continuing with characterization experiments in the RF regime and hope to publish a paper on these results later in FY2016. The gun will then be transferred to the SCA.

５．主な発表論文等

（研究代表者、研究分担者及び連携研究者には下線）

〔雑誌論文〕（計 0 件）

〔学会発表〕（計 0 件）

〔図書〕（計 0 件）

〔産業財産権〕

○出願状況（計 0 件）

名称：
発明者：
権利者：
種類：
番号：
出願年月日：
国内外の別：

○取得状況（計 0 件）

名称：
発明者：
権利者：
種類：
番号：
取得年月日：
国内外の別：

〔その他〕
ホームページ等

６．研究組織

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