JFY2012 Progress Report on the
"Research of High-Gradient Acceleration Technology for Future Accelerators"

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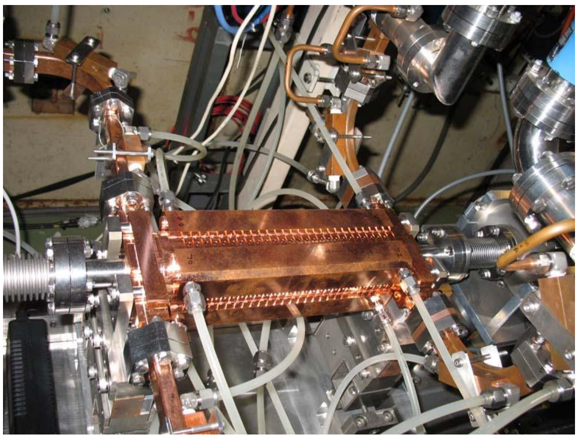
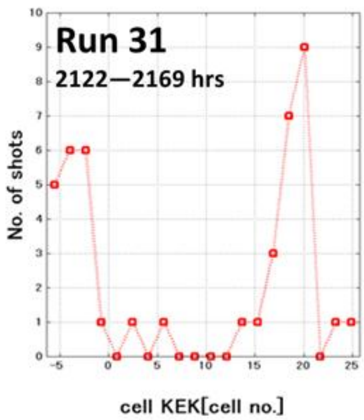
Four normal-conducting accelerator structure prototypes, TD24R05, for linear collider have been fabricated in collaboration between SLAC and KEK. One of them was high gradient tested at KEK as shown in Fig. 1 (left) and found the reasonably fast ramping of field gradient. However, it suffered the frequent breakdowns at some particular locations of the structure, as shown in Fig. 1 (right), after going into a bit higher peak power and longer pulse length than those for CLIC-type linear collider, namely > 100MV/m and > 250nsec. This experience, firstly encountered in the tests at KEK, forces us to make efforts to strengthen the basic studies on materials, material treatments and processing procedures.



Prototype test setup



Two hot cell regions

Fig. 1. High gradient test or prototype structures.

This effort is exactly in the line that we have been preparing under the US-Japan program exploring in the test setup with the simpler configurations. The first setup was established and now waiting for the power from the klystron replacing the failure klystron. The setup is shown in Fig. 2.

The first test sample is in our hand, and the following samples are under series of fabrication process. One of them is the quadrant-type as shown in Fig. 3.

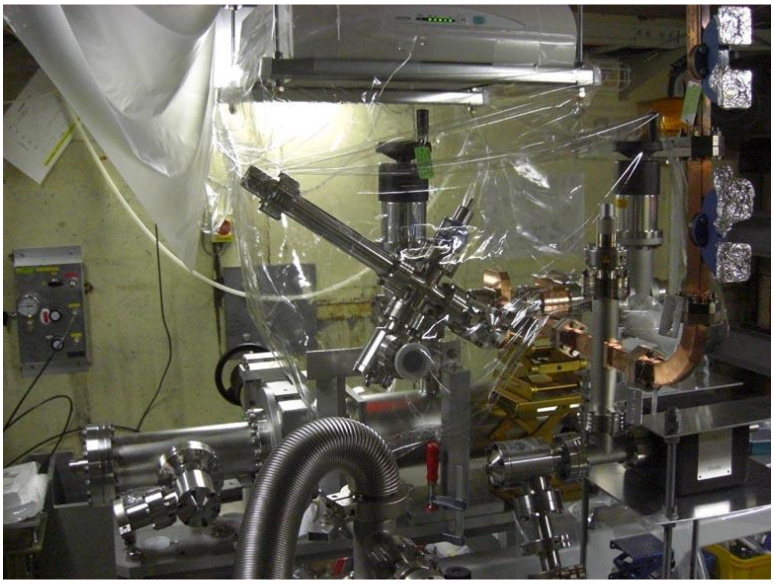
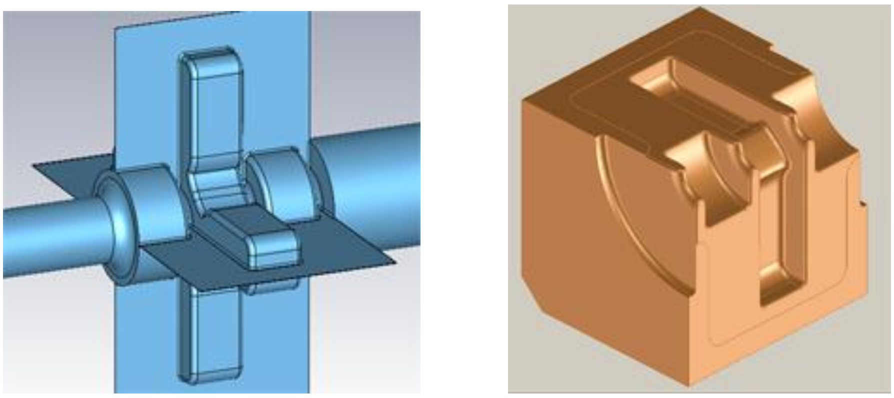


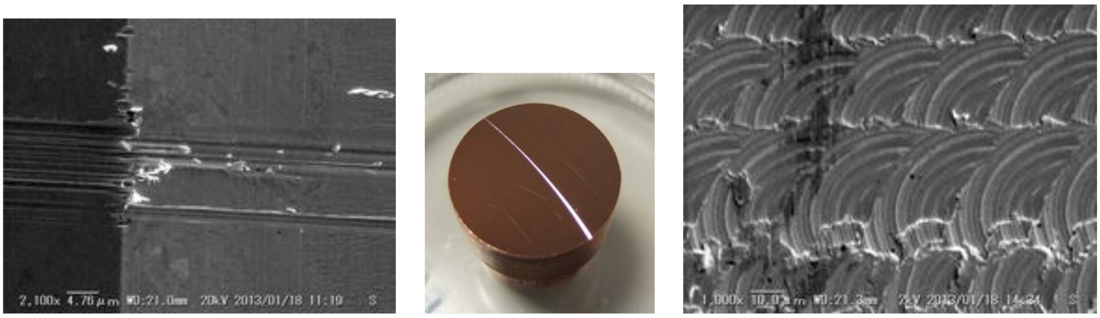
Fig. 2. Setup for the basic simple geometry experiment.



Whole single cell setup One quadrant block

Fig. 3. Quadrant-type cavity schematic.

Understanding the physics governing the vacuum breakdowns has become one of the most important issues for obtaining the stable high-gradient operation, such as the linear collider. We found that one of the key parameters was the magnetic field. The surface magnetic field is enhanced at the non-smooth points on surface. We made test coupons made of large-grain copper material (>99.9999%) to study the surface characteristics in relation to the material, fabrication and high-temperature heat treatments. The typical samples are shown in Fig. 4, showing the artificially-made scratches and ball-point end-milled surface. We are tracing how this surface nature changes as the following processes, especially the high-temperature process.



Ridge shaped by turning and artificial scratches　　Coupon　　Ball-point end milled

Fig. 4.　SEM view of surface of test coupons as of machined.

The hard material seems to have potential to reach much higher gradient. Fig. 5 shows the results obtained at SLAC that the hard copper, especially Ag-doped copper, showed much higher gradient with the same breakdown rate. It also shows the deterioration after the high gradient operation, meaning that we need to understand the evolution of the surface depending on the operation. This example again pushes us to study more specifically how the breakdown is governed by which parameters, not only surface but also bulk crystal nature.

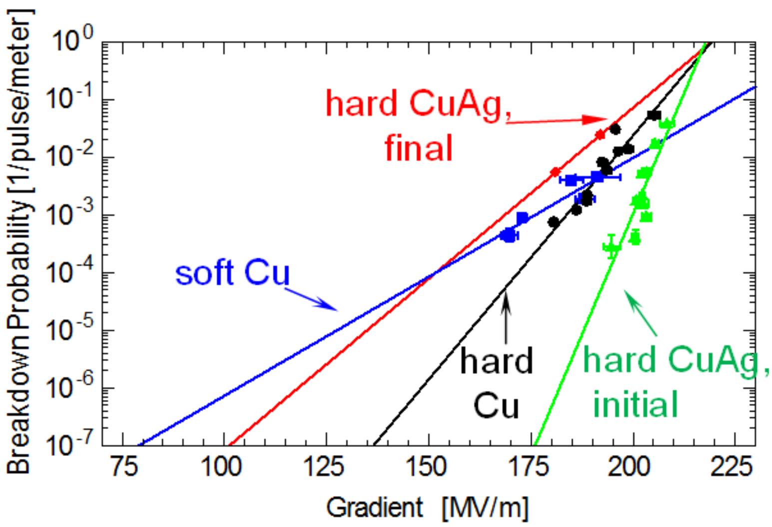
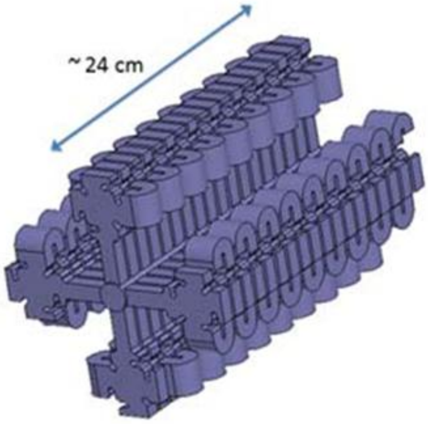


Fig. 5.　Breakdown rate in hard copper and soft one.

At SLAC, much higher gradient than 100 MV/m is studied from the RF feeding point of view with the standing-wave (SW) cavity in mind. The schematic designed by SLAC and the actual test plates for it made by KEK are shown in Fig. 6.



Schematic of SW cavity Plate for the SW cavity

Fig. 6. Schematic of parallel feed SW cavity and parts for it.

One of the main themes of the present program is to study the feasibility of the linear collider based on the high gradient studies compiling the studies until recent years. A simple idea is shown in Fig. 7, which shows almost the same configuration as the NLC/GLC stage, but citing a higher gradient. This is proposed a low-energy Higgs factory realized in a compact area in mind.

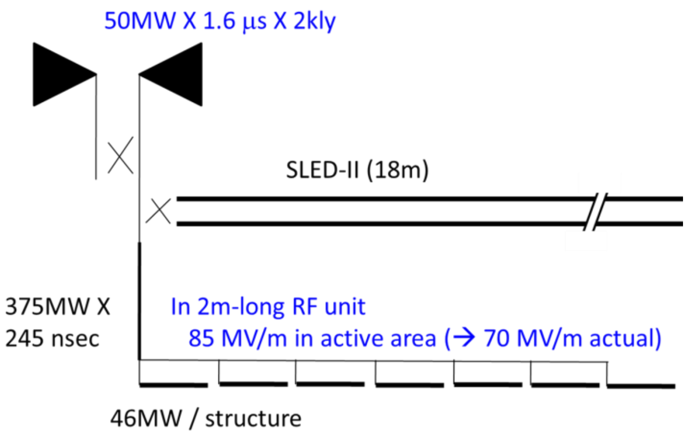


Fig. 7. RF unit under study as an outcome of this program.