INSPECTION CAMERA FOR SUPERCONDUCTING CAVITY AT IHEP

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Abstract

The first 1.3GHz low-loss large grain 9-cell superconducting cavity for ILC was fabricated at the Institute of High Energy Physics (IHEP) in April, 2010. The gradient of the cavity reached 20MV/m on the first vertical test in KEK in June, 2010. The gradient was limited by quench and field emission of the ninth-cell of the cavity. To locate the position of defects and improve surface processing, we have developed a high resolution inspection camera for the 1.3GHz 9-cell superconducting cavity of IHEP to check the cavity surface and make comparison. The camera is suitable for single and multi-cell 1.3GHz superconducting cavities. As there are several types of cavity under developing in IHEP, the camera was designed to be suitable for different type and frequency cavities like 500MHz BEPC II superconducting cavity, 1.3GHz TESLA and TESLA-like cavity, 1.3GHz and 650MHz low-beta cavity.

INTRODUCTION

In April, 2010, Institute of High Energy Physics (IHEP) had fabricated the first 1.3GHz low loss large grain superconducting cavity (IHEP-01) for ILC in China. The gradient of the cavity reached 20MV/m on the first vertical test in KEK in June, 2010. The cavity quenched at 20MV/m with strong field emission. The cavity was checked by Kyoto camera [1] on the ninth-cell and some small welding defects were found on the equator part which is the end of the EBW welding seal. However no defect was found on the iris. As inspection was needed for the second processing before the second vertical test in KEK, a high resolution inspection camera for the IHEP01 cavity was designed and fabricated.

PRINCIPLE

There are welding seams on the equator and iris of the superconducting cavity. Defects caused by welding are around these two regions. Considering the need to observe both iris and equator, we put the camera at the outside of the cavity to take good pictures.

A small mirror about 2cmx2cm is put in the center of the cavity supportted by a standing still tube and it can be rotated back and forth. The camera at the outside of the cavity takes pictures of the inner surface of the cavity through the mirror. As the mirror can be rotated, sharp pictures can be taken for the cavity wall area even it has a big angle to the cavity axis. The cavity can move along and around the cavity axis itself. All of the inner surface of the cavity can be easily viewed while moving and rotating the cavity and rotating the reflection mirror.

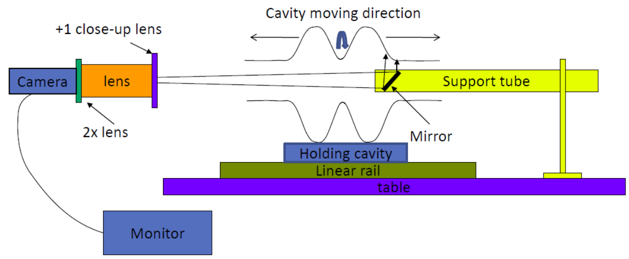

Figure 1: Principle of inspection.

To get a high resolution and sharp picture, we use a long focusing lens of 1000mm focus length and an achromatic close-up lens (cannon 500D close-up lens). The possible observing distance of the achromatic close-up lens is between about 40cm and 50cm. This length is enough for checking four end cells near the beam pipe. To inspect the other four end cells at the other end of the cavity, we need to rotate the cavity from one end to the other. We can use +1 close-up lens which is not achromatic instead of cannon 500D close-up lens to observe the other five cells at the other end of the cavity. However the resolution and the picture sharpness of using +1 close-up lens is worse than using the achromatic close-up lens. The maximum resolution of the camera system is about 3.6μm/pixel at the near end while using cannon 500D close-up lens.

Light system is the most important part of the camera. Good lighting will give sharp pictures of the cavity surface. Two light solutions were designed for the iris and equator separately. We use LED light as the light source and it was covered with different thickness papers to adjust the brightness.

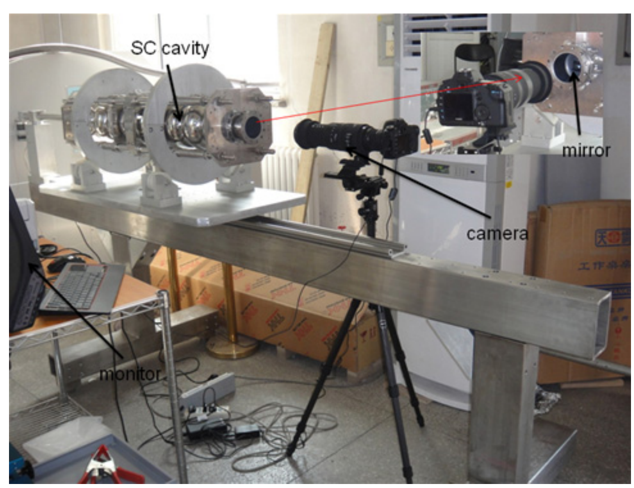

Figure 2: 1.3GHz low-loss large grain 9-cell superconducting cavity inspection system.

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INSPECTION ON IHEP-01 CAVITY

After the first vertical test, the 1.3GHz low-loss large grain cavity was processed again to eliminate the defects on the ninth-cell. CBP & BCP were taken for the cavity. 150µm was removed by CBP and 60µm was removed by BCP. After BCP, the cavity was inspected by the camera as it was just finished.

We have taken pictures for the equator and iris of the whole cavity. And we have compared the surface before and after CBP & BCP processing. Fig. 3 shows the processing results at the equator of third-cell of the cavity.

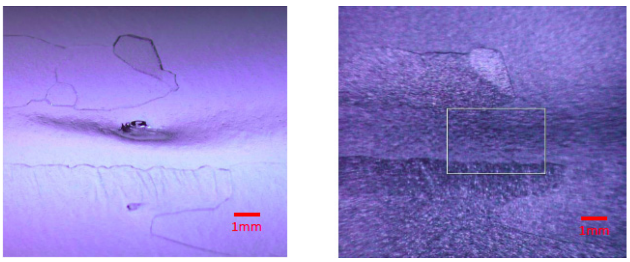

Figure 3: Surface comparison (85 deg @ cell # 3, Left: Kyoto camera, before CBP, Right: IHEP camera, after CBP&BCP)

We have found two pits on the iris of the IHEP-01 cavity after CBP&BCP for the first time by the new camera. One is located on the third iris and the other is on the eighth iris. The diameter of the pit is about 200µm.

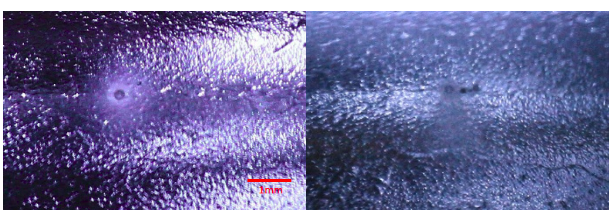

Figure 4: Pits on iris of IHEP-01 cavity after BCP (Picture taken by IHEP camera; Left: ~200µm diameter pit, 120 deg @ cell # 3&4, Right: ~90 deg @ cell # 8&9)

LIGHT IMPROVEMENT

Light is very important for getting sharp pictures. As reflection light from any part of the support tube will add a white background to the picture, we put black tape on the tube. Light angle and mirror angle have big influence on the sharpness too. Fig. 5 taken from the multi-dumbbell gives an example. We will test several light sources including plane light source later.

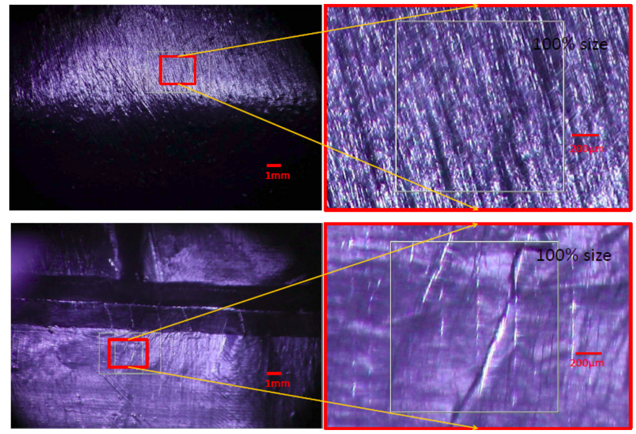

Figure 5: Influence of mirror and light angle (taken from multi-dumbbell with BCP, up: cavity wall between iris and equator; down: cavity wall near equator)

CONCLUSION

The IHEP camera was designed to suit for different type of cavities. It was tested on the 1.3GHz low-loss 9-cell superconducting cavity and good pictures were taken. However lighting is still a difficult problem to observe different parts of the cavity. New light system is under design and will be tested soon.

ACKNOWLEDGEMENT

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REFERENCES

[1] Y. Iwashita, D. Tajima and H. Hayano, PRST-AB, 11, 093501 (2008).