The Infrastructure for the TESLA Test Facility (TTF) - A Status Report

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Abstract

The TESLA collaboration is preparing the installation of a 500 MeV superconducting linear test accelerator to establish the technical basis for a future 500 GeV e^+e^- collider. The setup consists of 4 cryomodules, each containing 8 solid Niobium cavities with a frequency of 1.3 GHz. The infrastructure to process and test these cavities has been installed at DESY. The facility includes a complex of clean rooms, an ultraclean water plant and a chemical etching installation for cavity surface preparation and cavity assembly as clean as possible. To improve the cavity performance a firing procedure at 1500°C in an ultra-high vacuum furnace is foreseen. An existing cryogenic plant has been modified to cool down the cavities to 1.8K and measure them in vertical and horizontal test cryostats. The RF power will be provided by a 4.5 MW klystron (pulse length 2 ms) in connection with a modulator. This system will also be used for a high peak power RF treatment to further improve the cavity performance by eliminating potential sources of field emission. The components of the complete infrastructure for the TTF are described and their status is reported.

1. INTRODUCTION

The theoretical accelerating gradient in a Niobium superconducting cavity is limited to around 50 MV/m by the maximum value of the magnetic surface field occuring at the cavity equator. In praxis the gradient is limited to substantially lower values by field emission from localized regions of the cavity surface. In the past few years however there has been dramatic progress both in the understanding of field emission mechanism and in its cures. By means of ultrahigh vacuum baking at 1500°C under carefully controlled conditions or by high peak power RF processing (HPP) developped at Cornell multicell structures at S- and L-band frequencies have exhibited more than 20 MV/m accelerating gradients as demonstrated in fig.1 and fig.2.

To develop the surface treatment methods and the fabrication procedures required to produce high gradient multicell cavities on an industrial scale the TESLA collaboration first plans to construct and test forty 9-cell 1.3 GHz solid Niobium Cavities [1].

The necessary semiconductor standard clean rooms and the surface treatment facilities to process these cavities have been installed at DESY together with the equipment to test the cavity performance.

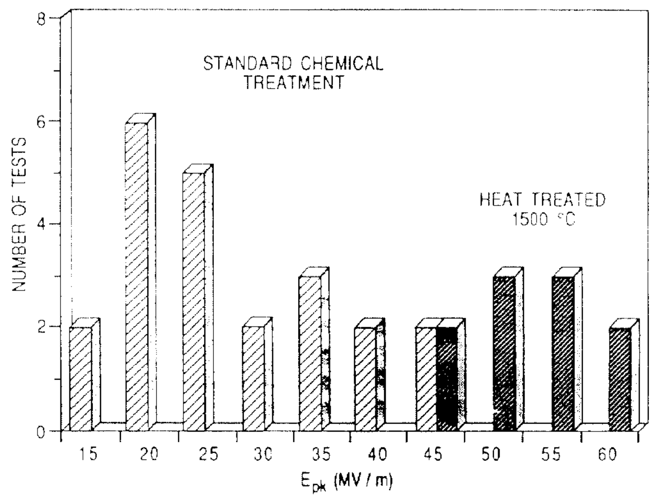

Fig.1. Improvement of cavity performance by heat treatment.

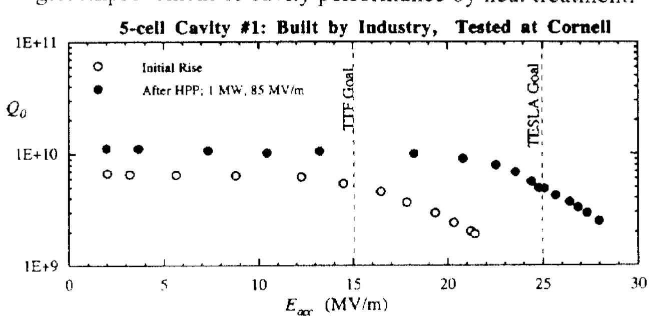

Fig.2. Improvement of cavity performance by HPP.

The most important components of this infrastructure are

- A complex of clean rooms (300m²) for dustfree cavity assembly and treatment, to avoid cavity contamination,
- A chemical etching facility complying with the purity standards of semiconductor industry,
- An ultraclean water supply for rinsing the inner cavity surface to remove potential sources of field emission,
- An UHV furnace to bake out the cavity at 1500°C to improve the Niobium material properties and to eliminate field emitters,
- A high peak power RF facility to process cavities for further reduction of field emission,
- Vertical and horizontal Helium cryostats to cool down and test the cavity performance at 1.8 K,
- A cryogenic plant to provide liquid Helium at 1.8 K and

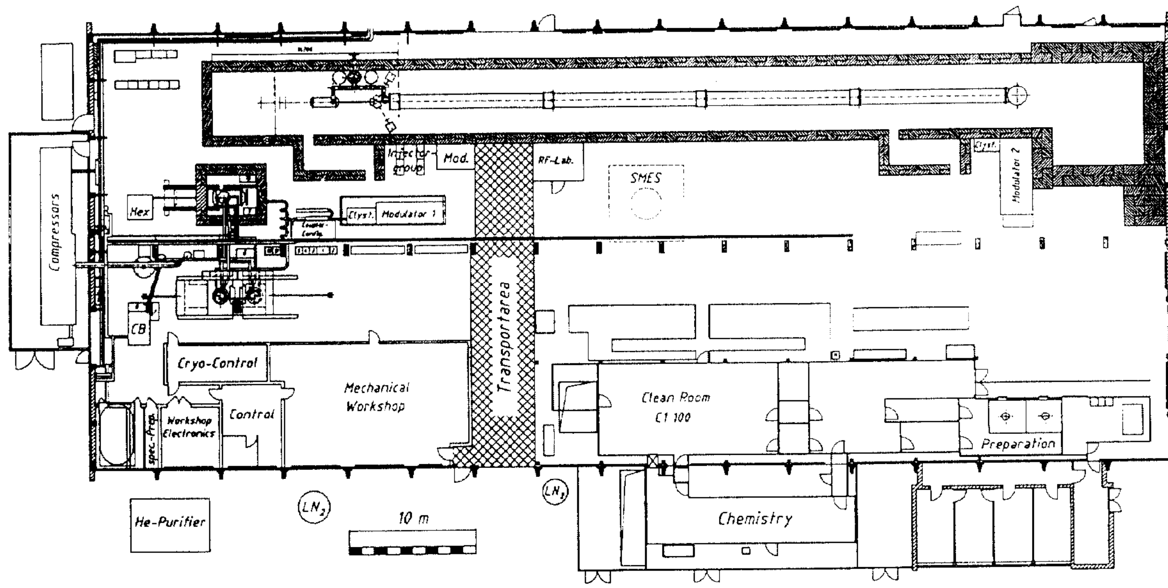

Fig.3. Overview of the TESLA Test Facility (TTF) at DESY.

4.5 K as well as Helium gas at 70 K for the cryostats and the planned test facility linear accelerator.

2. COMPONENT STATUS

The TESLA Test Facility (TTF) is located in an experimental hall of about 3000 m^2 surface area, which also houses the planned 500 MeV superconducting linear accelerator [2].

An overview of the TTF is shown in fig.3.

2.1 Clean room and assembly area

In order to avoid contamination of the cavity surface during processing and assembly a clean room has been built with an area of approx. 300m^2. The complex is divided into different classes, ranging from class 10000 down to class 10 (Federal standard 209), the last one being used for the most critical operations like connecting the cavities to a string for a cryomodule or mounting the input couplers to the cavity. Integrated in the clean room is the UHV furnace and the area for the chemical etching of the cavity surface. The clean room is operational since September 93.

2.2 Chemistry

Inside the chemistry area a cabinet for etching of the Niobium cavities is installed. The acid in use is a mixture of $HF/HNO_3/H_3PO_4$ of VLSI quality in a 1/1/2 ratio. The acid is circulating in a closed loop between the cavity and the storage tanks, which are located in a separate room outside the cleanroom. The pumps, tubes (made from PVDF) and filter elements (0.2μm size) of the chemical distribution system fulfill the standards of semiconductor industry.

Two different acid treatments are foreseen. The outside treatment removes the Niobium-Titanium surface layer after the postpurification in the furnace whereas the inside treatment with highest quality requirements is used for the preparation of the inner RF surface. The temperature of the acid can be set between 0° and 20°C with a mass flow of up to 20 ℓ/min. The process itself and the safety interlocks are controlled by a computer to reach high safety and reproducibility standards. After the etching process the cleaning procedure is finished by an ultrapure water rinse and a drying in an ultraclean hot nitrogen atmosphere.

Fig.4 shows the mounting of a cavity in the chemistry. The chemical facility has already been used for etching the first prototype TESLA cavities at DESY.

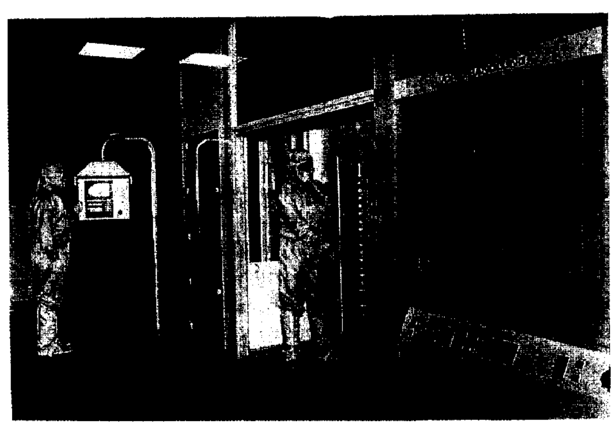

Fig.4. Cavity assembly in the clean room

2.3 Ultrapure water supply

An ultrapure water plant supplies the cavity cleaning facilities with water of 18.2 MΩ·cm resistivity under (nearly) particle free conditions. Its first stage consists of a reverse osmosis unit (300ℓ/h), the second stage is equipped with nuclear grade mixed bed ion exchangers, augmented by filters and an ultraviolet light source. The point of use filters have a mesh size of 0.04 μm. A storage tank of 4000ℓ capability allows the use of large quantities of ultrapure water for cavity surface rinsing and cleaning. This plant is a continuous operation since August 93.

Added to this facility is a high pressure rinsing station (up to 200 bar), which has been developped and built by CERN. This unit allows the ultimate cleaning of the inner cavity surface and is presently being commissioned (May 94).

2.4 UHV furnace

Heat treatment of the complete cavity reduces potential sources for field emission and improves the Niobium material properties like thermal conductivity (RRR) and homogeneity. During this process (at 1500°C and a vacuum of 10^{-7}mb) Titanium is evaporated and builts up as a film on the outer cavity surface. This effect leads to a solid-state gettering process for residual gases during high temperature annealing. The furnace for the TESLA cavities, which is shown in fig.5 has been delivered and will be commissioned with prototype cavities in August 94.

2.5 High power processing (HPP)

Besides heat treatment in an UHV furnace the application of high power RF pulses (≈MW) for a short time (≈ms) to the cold cavity has proven as very effective to remove potential field emitters from the inner cavity surface. To apply this method for the TESLA cavities an HPP test stand has been built. It consists of a modulator supplied by FNAL and a klystron with a peak power of 4.5 MW at a pulse length of 2ms. This setup (shown in fig.6) is connected through RF wave guides with the vertical and horizontal cryogenic cavity test stands. First HPP treatment of a TESLA cavity is expected in July 94.

2.6 Cryogenics

For cooldown and test of the TESLA cavities an existing liquid Helium plant has been extensively modified. By adding vacuum pumps and screw compressors a temperature of 1.8K can be reached, with a refrigeration power of 200W. The unit, which in addition provides Helium at 4.2K (900W) and 70K (2000W), is connected to two vertical cold test stands built by FNAL and a horizontal test cryostat provided by CE Saclay. The liquid Helium plant is operational since December 93.

3. SUMMARY

For the TESLA Test Facility (TTF) at DESY the complete infrastructure for superconducting cavity processing and testing has been built during the last 18 months. The components are in operation and commissioned with two prototype TESLA cavities. The arrival of the first series cavities for the test linac is expected in August 94.

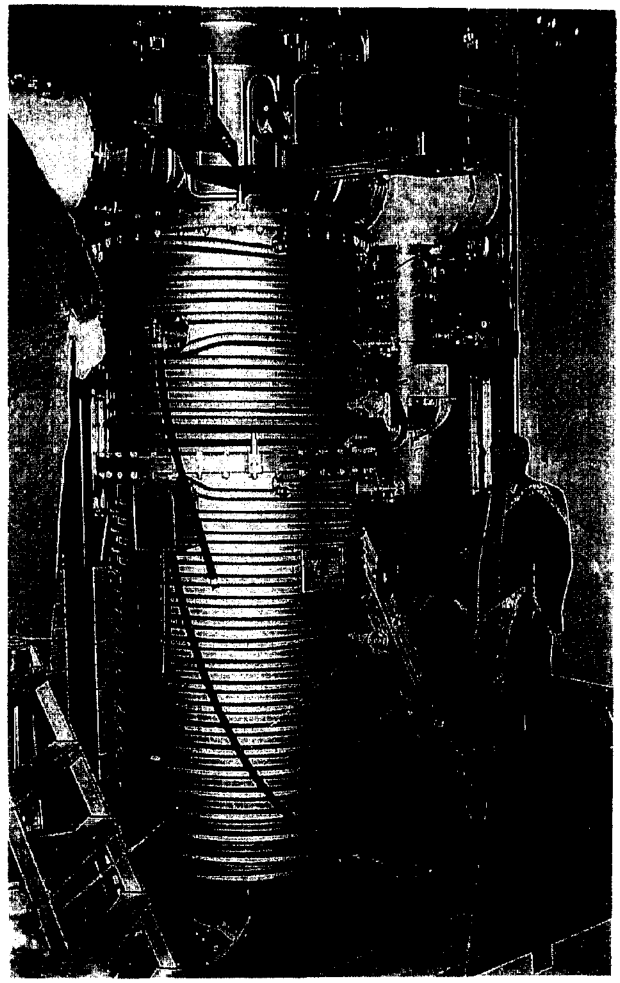

Fig. 5. UHV furnace for heat treatment.

Fig.6. RF setup for HPP treatment.

4. REFERENCES

[1] Proposal of the TESLA collaboration. TESLA Report 93-01.

[2] H. Weise, DESY, for the TESLA collaboration. Contribution to this conference.