TITANIUM COATING AND RESONANT RING TEST OF OUTPUT WINDOW FOR KLYSTRON

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Abstract

Coating on the output window of klystron with Ti compound is necessary for preventing from fractuaring. We make specimens of thin films of TiOx and TiN by means of electron beam deposition method and DC sputtering method. Evaluate them in the view point of thickness and component by method of EPMA, RBS, AES and XPS.

We tested titanium compound coated window : AL−300, AL995 and AD995 using resonant ring of SLAC,

1. Preface

It is well known that output window of klystron is sometimes damaged when high power of microwave goes through it. In order to prevent these accident, it is needed to use the window made of higher purity ceramic and to coat it with thin film of titanium compound.

We will report on the titanium coating that we are now developping and the resonant ring test of our windows at SLAC.

2. Methods of coating

We have two methods of coating : electron beam deposition method and direct current sputtering method. The former is an established technique and the latter is now being developed.

Outline of DC sputter equipment is shown in Figure 1. This equipment is composed of high voltage power supply, gas inlet system and vacuum system. The target (titanium plate) is settled on the cathode. And output window on which thin film is going to be deposited is settled on the anode which is usually kept at the ground voltage. Wide range turbomolecular pump (280L/s) and rotary pump are used as pump system. Pure argon gas or mixture of argon gas and nitrogen gas is selected as discharge gas according to the kind of titanium compound.

Main controlling factors of the equipment are gas pressure, imposed voltage and discharge current. But only two of them are controllable independently. We control pressure and voltage

in our sputtering work. The discharge current is sensitive to voltage and / or pressure.

Specimens were made by coating glass plates adhered on the window ceramic with the titanium compound film. Titanium nitride films were made in the atmosphere of mixed gas of argon and pure argon gas.

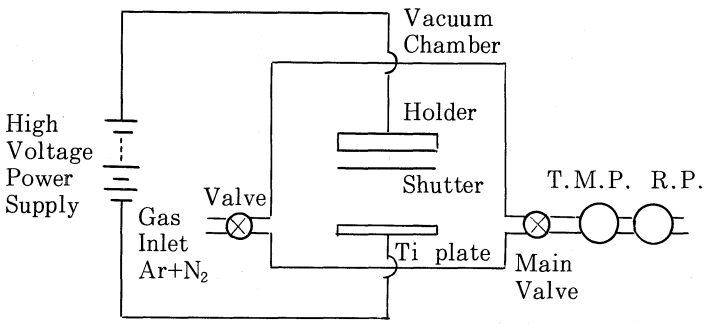

Fig. 1 Outline of DC Sputter equipment

3. Evaluation of thin films

Specimens were evaluated by two points of view : thickness and component. Thickness was measured by EPMA (Electron Probe Micro Analysis) method and RBS (Rutherford backscattering Spectroscopy) method. Component were analysed by AES (Auger Electron Spectroscopy) and XPS (X−ray photoemission spectroscopy).

Table 1 shows the results of these measurements and analysis.

Table 1

		Thickness		Component	
No.	specimen	EPMA	RUS	AES	XPS
1	Electron Beam Deposition	1 (100 Å)	21 Å	Ti, 0	.....
2	Ti0x (DC sputtering)	1	.....	Ti, 0	.....
3	TiN (DC sputtering)	0.7	.....	.....	Ti, 0, N

We could get a DC sputtered film which had the some thickness as electron beam deposited film. As to components of the films both films deposited by DC sputtering method in pure argon gas and those deposited by electron beam deposition method had the same components : titanium and oxygen. As for the film deposited by DC sputtering method in the nitrogen-argon mixed gas, nitrogen was detected in the film.

As for the films which were made by electron beam deposition method, RBS method was also used to measure absolute thickness of the films. As shown in figure 2 specimens were made by coating the small carbon disk sdhered on the aluminum disk with titanium film. Result is shown in the table 2. Values express the numbers of atoms on a units square centimeter of the film.

Table 2

Specimen No.	Number of Atoms (/ cm^2)	Specimen No.	Number of Atoms (/ cm^2)	Specimen No.	Number of Atoms (/ cm^2)
1	2.70×10	5	3.10×10	7	2.76×10
2	2.82×10	6	2.61×10	8	2.96×10
3	2.62×10			9	2.42×10
4	2.8 ×10			10	2.40×10
av.	2.76×10		2.81×10		2.64×10
Average of all speciman			2.73×10		

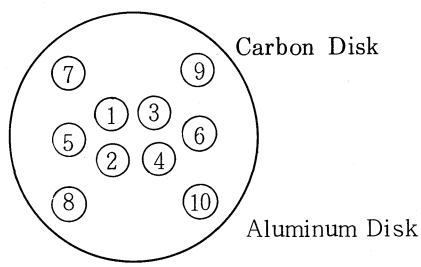

Fig. 2

Thickness is got by the following fomula

$$d = \frac{\sigma M}{\rho N_A}$$

where M is atomic weight, N is Avogadro number, ρ is density and σ is the numer of atoms in the 1 cm square. The measured thickness of the films made by this method was 21± 3 Å. There were considerable difference among each specimens. But they also involve errors of measuring equipment. It we assume the specimens on the same concentric circle belong to the same group, differences among the same group were lessthan 5%, So the thickness of the films were almost equal. On the other hand as to the films obtained by DC sputtering method, the difference of thickness between the specimens on the edge of the window and on the center of the window was more than 30%. We will improve the sputtering equipment in order to get more uniform film.

4. Resonant ring test

We tested output window of PV−3030 using SLAC's resonant ring twice. The first test was done using three of MELCO windows of AL−300, two of which were coated with TiOx by MELCO and one of which was coated with TiN by SLAC. These date are compared with SLAC window of AL−300 coated with TiN by SLAC. The second test

was done using one MELCO window of AD−995 which was coated with TiOx by MELCO. This data is compared with two SLAC windows of AL−995 coated with TiN by SLAC. Figure 3 and Figure 4 show the comparison between AL−300 and AD−995 in MELCO windows. These test were done due to the standerd test procedure of SLAC resonant ring, pulse repetition rate of which is 180pps and pulse width of which is mainly six microseconds but two microseconds at the first short period. The followings are conclusions of the test results :

(1) There is not difference of window performance between MELCO windows and SLAC windows in the range of 100 MW−108kW.

(2) Effect of TiN coating in not remarkably different from that of TiOx.

(3) There is a distinguished improvement from AL−300 to AL−995 or AD−995 which has content of 99.5% alumina, while AL−300 has 97% alumina contents.

(4) Window temperature and loss are determind mainly by average power through window.

These tests were done keeping both sides of the windows under high vacuum. Also window configulations for both cases are completely the same except for contents of alumina disk.

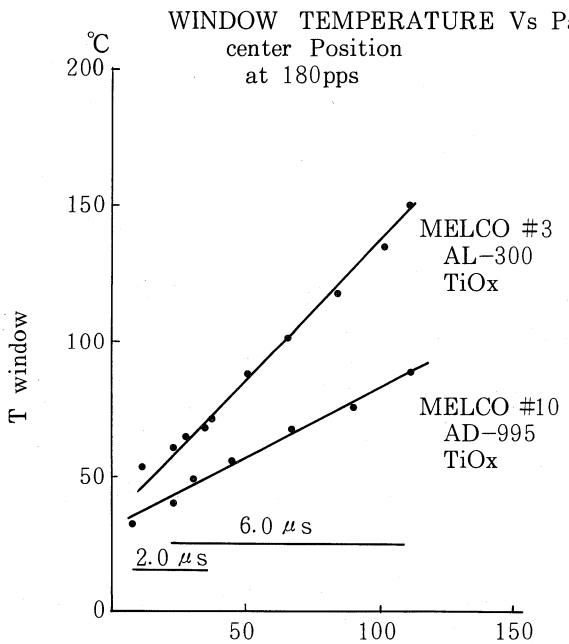

Fig.3

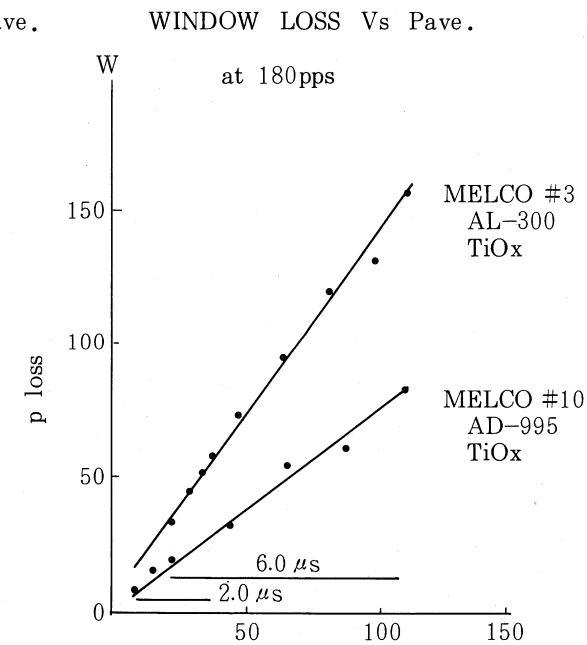

Fig.4

5. Acknowledgement

We thank to Dr. Hanaki of KEK. He measured the thickness of specimens of titanium oxide by RBS method for us.