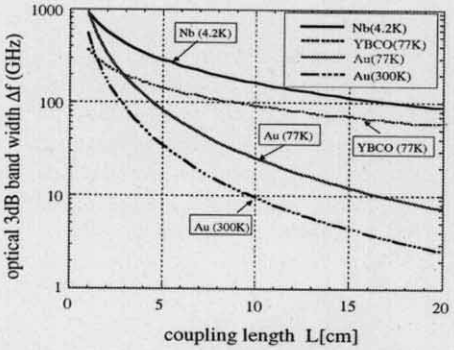

Fig.4 Calculated optical 3dB band width Δf as a function of coupling length L

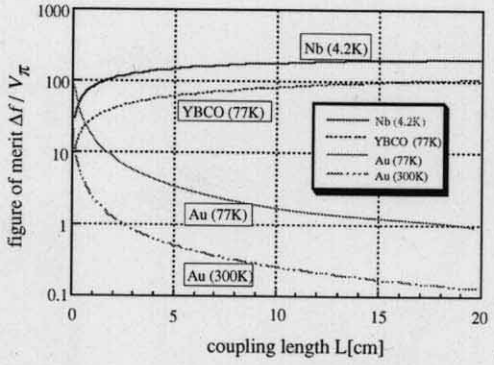

Fig.5 Figure of merit Δf/Vπ as a function of coupling length L

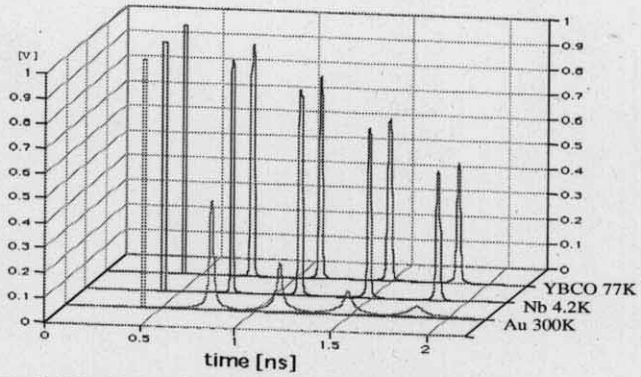

Fig.6 Waveforms of a pulse traveling in various electrodes (at L=0,5,10,15,20cm from left)

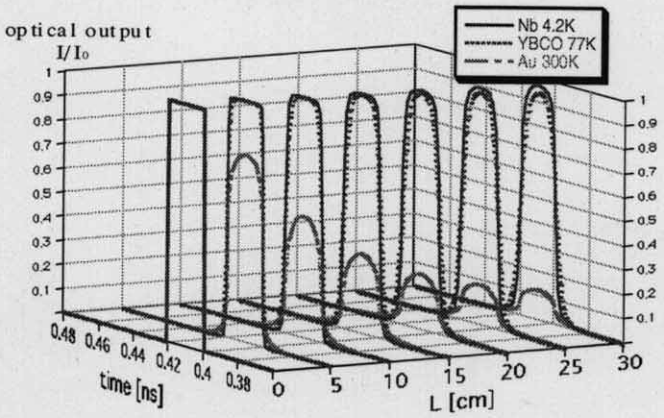

Fig.7 Optical output waveforms in various electrodes

III. EXPERIMENT

The optical modulator used in the present experiment was the traveling-wave type Mach-Zehnder optical modulator with a shielding plane as shown in Fig.8. Dimensions of the modulator is described in detail in [8]. We used y-cut $LiNbO_3$ substrate whose edges were mirror polished, and single mode optical waveguides were formed by Ti diffusion into the surface of the substrate. The transmission line for the signal wave and the shielding plane were made of NbN. The coupling length L was 20mm. The fabrication process of the shielding plane is shown in Fig.9. We made the shielding plane with the various heights from 3μm to 7μm for velocity matching.

In the experiment we used a semiconductor laser with the wavelength of λ=1.3μm. In order to guide laser light into the optical waveguide in $LiNbO_3$ substrate we used a polarization maintaining fiber at the input end and excided a TE mode in the optical waveguide. We attached optical fibers to the mirror polished edge of the substrate. The connection betweeen optical fibers and $LiNbO_3$ substrate was made by an adhesive which is hardened at illuminating ultra-violet light with the use of minute glass tubes.

For measureing microwave modulation characteristics in the frequency range between dc and 26.5GHz, we adopted the envelope detection method [11], [12], where the microwave response of the modulator can be estimated by the time averaged response of the powermeter even in the case when the cutoff frequency of the powermeter is much lower than the microwave frequency.

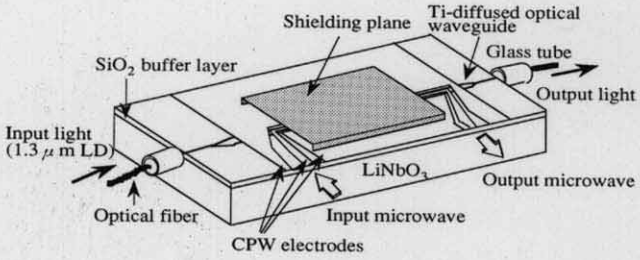

Fig.8 Schematic of a traveling-wave-type optical modulator with a shielding plane

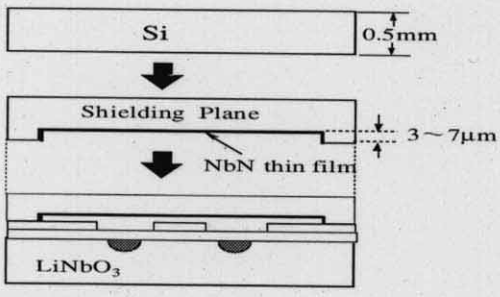

FIg.9 Fabrication process of a shielding plane