Characterization of waveguide components for the ALMA band 10

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The Atacama Large Millimeter and Submillimeter Array (ALMA) band 10 cartridges are being designed based on use of waveguide components such as couplers, because of their mechanical ruggedness and reliability. Although recent machining technology makes it possible to fabricate such small waveguide components with sizes of down to several tens of microns, it is important to characterize their electrical performance experimentally at room and cryogenic temperatures. For the room temperature measurements, we have developed a vector network analyzer, which consists of a W-band Gunn oscillator followed by a nonupler as a transmitter and a subharmonic Schottky diode mixer pumped by another W-band Gunn oscillator as a receiver. Both Gunn oscillators are phase-locked to a single microwave reference, but on different sidebands. The device under test (DUT) is put between the transmitter and the receiver and the insertion loss and phase difference is measured. For the cryogenic temperature measurements, we used SIS mixers consisted of a corrugated horn and a mixer block. These are connected by a common waveguide flange. The DUT is inserted between them. By measuring the mixer gains or noise temperatures with and without the DUT, the insertion loss is simply estimated from the change of the gains or noise temperatures due to the input loss.

Figure 1 shows a photograph of a 10-dB directional coupler with WR-1.2 (0.305×0.152 mm) gold-plated waveguide made by machining. The total length of the waveguides is 30 mm. Figure 2 shows the measured insertion losses at room temperature. This result is reasonable if we assume an electrical conductivity of the gold at room temperature, which suggests that the part of the 10-dB coupler with two slits works well as expected. However, the insertion loss at cryogenic temperature showed a large loss of about 1.8 dB/30 mm. To confirm this unexpected waveguide loss, we measured the loss in a 25-mm-length straight waveguide as well. The result showed the waveguide losses of about 1.3 dB/25 mm, which is similar to the result of the 10-dB coupler. This implies that the length of the waveguide components should be designed as short as possible to reduce the waveguide loss in more than this frequency band.

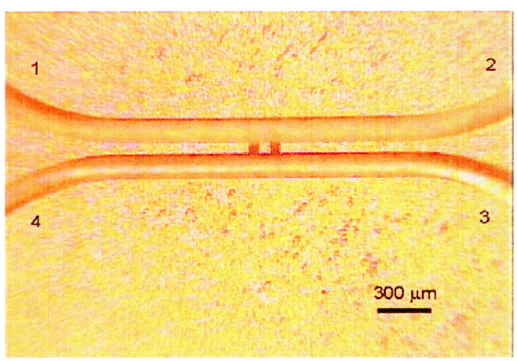

Fig. 1 A photograph of a 10-dB directional coupler at the Band 10 frequencies.

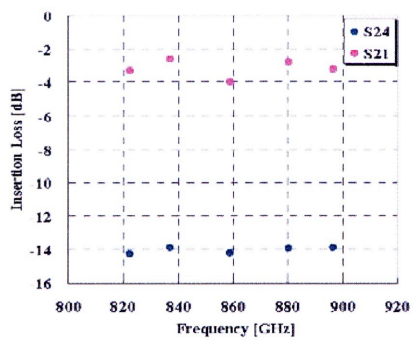

Fig. 2 Measured S-parameters as a function of frequency.