Design Accuracy of the Resonance Frequency for the PCTJ SIS Mixer

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We are developing a 640 GHz SIS mixer for JEM/SMILES[1]. To tune out the junction capacitance, we use a resonance circuit designed by the parallel-connected twin junction(PCTJ) approach[2]. For a certain resonance frequency, the length between two junctions (Lj) depends on the junction capacitance. Since the junction has to be large enough for its reliable fabrication, Lj becomes short for the resonance at 640 GHz. In that case, the resonance frequency is not accurately calculated from a simple assumption that Lj represents the effective inductance, because the junction size and the microstrip width are no longer negligibly small compared to Lj. We investigated the relation between Lj and the actual resonance frequency by means of a simple circuit model of the PCTJ for our 640 GHz mixer.

Figure 1 shows a photo of our PCTJ circuit. The junction size is nominally 1 μm x 1 μm. A 6.6 μm-wide microstrip connects the two junctions separated by Lj, which ranges over 7.45 - 11.45 μm. An analysis with a simple LCR circuit is not sufficient in that case, and we must take into account some spreading inductance of electric current. Our approach for that is to replace the superconductive PCTJ circuit with an approximate 3D structure of normal conductivity, which can be analyzed by means of a commercially available FEM tool. The replacement is done as follows:

(1) The superconductive microstrip is replaced with a normal microstrip that has the same width, same characteristic impedance, and same electrical length as the original superconductive microstrip.

(2) The SIS junction is replaced with a structure that has the same size, same capacitance, and same resistance, which is modeled with appropriate values for dielectric constant and conductivity.

The resonance frequency of that approximation model is derived from a 3D EM simulator (Ansoft HFSS), and it is compared with a result of a simple LCR resonance model. An effective spreading inductance, that is necessary to get the derived resonance frequency, is calculated and shown in Figure 2.

The simulated mixer performance and measurement results will be also reported at the symposium.

References

[1] SMILES Science Team and SMILES Mission Team, "JEM/SMILES Mission Plan", Version 2.1, November 2002 (available at http://smiles.tksc.nasda.go.jp/index.shtml)

[2] T. Noguchi, S. C. Shi, and J. Inatani, "Parallel connected twin SIS junctions for millimeter and submillimeter wave mixers: analysis and experimental verification," *IEICE Trans. Electronics*, vol. E78-C, 481, 1995.

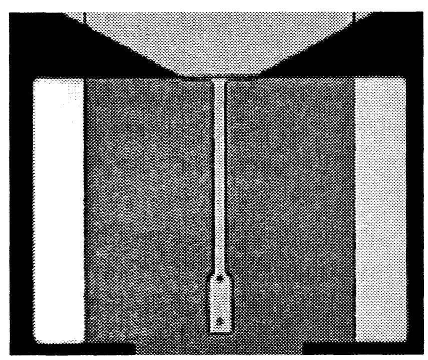

Figure 1. Optical microscope image of the 640 GHz PCTJ image.

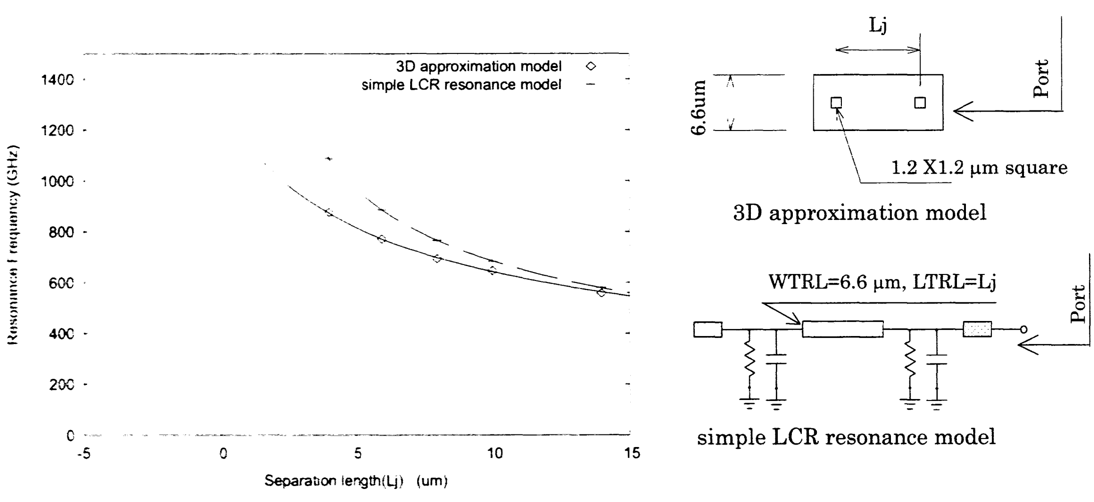

Figure 2. The resonance frequency as a function of junction separation length. Curves are the fits obtained with the expression $F_{res} \propto 1/\sqrt{(L_j + \Delta L_j)}$. For the case of 6.6 μm wide microstrip line .1.2 X1.2 μm square shape of junction, an acceptable fit is obtained with $\Delta Lj = 3.0$ μm.