RADIO CORPORATION OF AMERICA

Semiconductor and Materials Division

QUARTERLY REPORT No. 9

70mc, 1 Watt Silicon Transistor

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Production Engineering Measure

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For

U. S. Army Signal Supply Agency
Philadelphia, Pennsylvania

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I. PURPOSE

This is an Industrial Preparedness Measure Contract for the purpose of developing a manufacturing process to develop a production line for a 70 mc, 1 watt silicon transistor. Five hundred engineering samples and 2000 pilot line units will be submitted during the period covered by the contract and the feasibility of manufacture of 200 units per day demonstrated.

The transistor will have the following specifications:

Examination	Conditions	AQL	Inspection Level	Symbol	Limits Min.	Limits Max.	Units
Subgroup 1							
Collector Cutoff Current	V_{CBO} = 10VDC, I_E = 0			I_{CBO}	-	0.5	μADC
Collector Cutoff Current	V_{CES} = 100VDC, V_{EB} = 0	1.0%	I_I	I_{CES}	-	100	μADC
Emitter Cutoff Current	V_{EBO} = 5VDC, I_C = 0			I_{EBO}	-	100	μADC
Subgroup 2							
Output Capacitance	V_{CB} = 50VDC, I_E = 0			C_{OB}	-	5.0	μμf
Base Resistance	V_{CE} = 20VDC, I_C = 10mADC, f = 300 mc	1.0%	II	$R_{bb'}$	-	25	ohms
Small Signal Short Circuit Forward Current Transfer Ratio	V_{CE} = 20VDC, I_C = 25 mADC, f = 70 mc			h_{fe}	10	-	db

Examination	Conditions	AQL	Inspection Level	Symbol	Limits Min.	Max.	Units
Subgroup 3							
Oscillator Power Output	V_C= 50VDC I_C= 50mADC f= 70 mc			P_o	1.0	-	watt
Power Gain	V_{CE}= 50VDC I_C= 50mADC f= 70mc	2.5%	II	P_G	10	-	db
Saturation Voltage	I_C= 200mADC I_B= 75mADC			V_{CE} (SAT.)	-	1.0	volt

II. ABSTRACT

During this Quarterly Period, six different case finishes were evaluated after exposure to 200°C storage and salt atmosphere corrosion resistance tests. Results indicated gold plating to be the most satisfactory. The gold is solderable, does not discolor or peel on 200°C storage, and has a fair resistance to salt atmosphere. The greatest difficulty observed with the gold finish has been lead corrosion at the glass-to-metal seal during salt atmosphere testing.

Diffusion and metallizing processes were slightly modified to improve the BV_{CES} yields. However, degradation of collector breakdown voltage during assembly is still a production problem.

III. 70mc, 1 WATT SILICON TRANSISTOR

A. Case Finishes

Results from Pre-Production Testing indicate that the TA-1938, 1 watt, 70mc silicon transistor meets all Group A and B electrical specifications of the contract. These tests have been performed with the pellet mounted in a case with a TO-12 outline. This particular package was chosen early in the contracting period. To date, all samples submitted have been mounted on this stem. The TO-12 case is readily available, has the commonly used .200 inch pin circle, and easily meets the 3.5 watt, 25°C power dissipation requirement.

Since the TO-12 case has been found electrically, thermally, and hermetically acceptable. the only other requirement is to select a suitable finish. The device specifications as listed in the Signal Corps Technical Requirements include two tests for finish; (1) 200°C storage, and (2) moisture resistance. A common gold plating finish meets both of these environmental requirements.

It is anticipated that the final Military Specification will also include a solderability and a salt atmosphere test. Therefore, the available finishes were reviewed during this period in an attempt to determine which finish would be most suitable for this transistor.

The criteria for evaluating the finishes were: (1) solderability, (2) salt atmosphere, and (3) 200°C storage. Moisture resistance and soldering were not performed since a finish that can withstand salt atmosphere and 200°C storage is capable of withstanding both moisture resistance and soldering tests. Table I lists results of this testing.

FINISH	SOLDERABILITY	TEST SALT ATMOSPHERE HEADER	TEST SALT ATMOSPHERE LEADS	200°C STORAGE
Gold Plating	Good	Good	Fair	Good
Tin Plating	Good	Good	Good	Poor
Nickel Plating	Poor	Good	Fair	Good
Tin-Nickel Plating	Good	Good	Fair	Fair
Cadmium Plating	Good	Good	Good	Poor
Paint (on header only)	-	Good	-	Fair

TABLE I

CASE FINISHES FOR TO-12 PACKAGE

Test results listed in Table I indicate that finishes which are solderable and can withstand 200°C storage do not perform well on salt atmosphere. The main difficulty has been with corrosion of the leads at the glass-to-metal seal. This corrosion is probably due to exposure of unplated areas of the lead at the glass-to-metal seal. Flexing of the leads during testing removes a small amount of the glass overmold, exposing an unplated portion of the lead.

Gold plating and tin-nickel plating gave the best results. However, the fluoride bath used in the tin-nickel plating process corroded the glass in the glass-to-metal seal. This method of plating would probably not be practical unless the glass-to-metal seal is replaced by a ceramic-to-metal seal. Consequently, the gold plating appears to be the most promising finish.

B. YIELD IMPROVEMENT

Since the completion of pre-production testing, effort has been directed toward improving the overall device yield. The major area of shrinkage has been to the 100-volt V_{CES} requirement. There has been no difficulty in fabricating the collector-base diode with typical breakdown voltages of 130 volts. However, a gradual degradation of BV_{CBO} during the emitter formation, metallizing, and assembly reduced the yields considerably.

A general "cleaning up" and a tighter supervision of the process has improved the dice yield during diffusions. A dilute hydrofluoric acid rinse before aluminum alloying has cut down shrinkage at this step. Presently, pellet yields at the dicing operation are typically 20-30 per cent of the dice processed.

BVCBO degradation during assembly is still a problem. In particular, the alloying of the pellet to the stem has caused up to a 40 per cent reduction in collector breakdown voltage. Dropping the alloying temperature from 465°C to 415°C has helped this problem considerably. Effort will continue in this area to reduce the shrinkage at assembly.

IV. CONCLUSIONS

The environmental tests performed on the various case finishes indicates that a final gold plating step will provide a satisfactory finish for the TA-1938 transistor.

Closer control of the diffusion and improved cleaning during the metallizing operation have improved the BV_{CBO} yields.

V. PROGRAM FOR NEXT QUARTER

During the next Quarterly Period, effort will be directed toward further improving the product yields. Pilot production will be completed and the final report written.