³0 4B # U•2095-4980 2023 01-0016-06

C Kg j S ” z#U S6) ö ¢ % THz u*a #+° j S À*T

z D u [1,2]U•AY ¦ ó [1,2*]U•Eá .‘ [1]U•0R LTÅ[1]U• % öA [1,2*]

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„ >- K»,l VB— ¥ ¬ [z#U*a | ' ¸ 0*a U ³ '+° ý • U• % z#U(Û ¯ 7 ˆ+°Kò < -=ñ ;C Kg j S7Û's+°L,!n Ê Ì X ³I´ % ,.ù Ge Si & Á ·C Kg j S ” U• g>--@/¢ ² ¢# z#U(Û ¯ 7+°*a ' S6) U•8ã Ã ² 8 K#U Ò 7 j S ”7Û's+° ¤ ·0 *a"m *a ·'¥ S 3ë ¸ Ê+ö 3ë U• Ã \ ² T 0.1~3 GHz M½ R ±D¯ f Ÿ '+° Ê+ö t È Užf ²O¸@í ¢ % VB— ¥ u*a #+° j S Ë6) U• 2A C Kg j S ” : VB— ¥Fû |K] Î"w ”Kò < -=ñ U• ¢ Y & ² VB— ¥65 Þ$ì u Î"w2'4 U• T 8 K#U Ò 7 Ê(Ü ² %65 é 2 s VB— ¥ u*a Î"w #+° 5 t j S U•C Kg Ê+ö3Õ560 U•*a"m j S Ê+ö f 1.78 mA/V 6E -@/¢ < ÈNÂ MO¸@í ² r*TC Kg j S ” T# z#U(Û ¯ 7 À*T+° =x S U• f VB— ¥P EK Î"w :P M½EF M² +°Kò <C Kg j S ü Ç ² ,.ù 5 t ¬ [w á

ŸJZ@ù VB— ¥ Î"wUžP EK -=ñUžC Kg j S ” Užz#U j S ¬ [
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Low temperature performance of transimpedance amplifier and its application in amplification of terahertz photoelectric signal

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Abstract With the development of terahertz technology, low temperature electronics and radio astronomy, the demand for integrated transimpedance amplifier chips working in low temperature environment increases. The electrical performance of a Ge Si based transimpedance amplifier in deep low temperature environment is studied. The current voltage curves of the typical ports and gain curve of the amplifier chip at 8 K, and a relatively flat gain effect in the 0.1 GHz 3 GHz band are obtained. In order to verify its amplification function of terahertz photoelectric signal, GN1068 is integrated with terahertz Quantum Well Photodetector(QWP), and a terahertz pulse laser detection system is built. A terahertz photoelectric signal, with a pulse width of 2 s, is successfully amplified at 8 K. The transimpedance gain is about 560 . The current amplification gain is 1.78 mA/V. The above results verify the feasibility of commercial transimpedance amplifier in deep low temperature environment for the first time, and provide an effective technical means for integrated transimpedance amplifier in the field of terahertz high-speed detection and high frequency communication.

Keywords terahertz detectingUžhigh speed packagingUžtransimpedance amplifierUžcryogenic amplification technique

(THz) 0.1~10 THz 3 mm~30 m
THz
[1]

b/k K U•2022-04-25 K U•2022-05-17
&FýM¥, U• (2018YFB1801502) (61927813 61775229 62004209 21DZ1101102)

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THz THz THz
1 THz [2]
(Superconducting Hot-Electron Bolometer SHEB)[3] (BIB)[4-5] (Schottky Barrier Diode SBD)[6] THz (QWP)[7]
1~10 THz
THz QWP Liu [7] 2004
[8-14] THz QWP [15]
THz QWP (Light Emitting Diode LED) [16] THz THz QWP LED
THz
THz QWP LED
THz QWP
Patrashin [17] 4 THz QWP 4 K
THz QWP
THz

(Junction Field-Effect Transistor JFET) 100 K
(Bipolar Junction Transistor BJT)
(Complementary Metal Oxide Semiconductor CMOS)
[18] [19]
40 K
THz
100 MHz[20]
Ge-Si (GN1068) THz QWP

THz QWP THz
QWP 100 GHz
[21] THz QWP QWP
1 THz THz QWP
THz QWP GN1068
8 K THz QWP THz
GN1068 THz QWP GN1068

1 7Û's -=ñ

GN1068 Ge-Si
250 m 1 210 m×
900 m -3 dB 12 GHz(16 G)
6.75 k
1 GN1068
THz QWP 800 m×800 m
[22] THz QWP GN1068
mm

THz QWP

Fig.1 Micrograph and main pins of the GN1068
1 GN1068

THz [11] THz QWP

THz QWP

2 THz QWP GN1068

(Printed Circuit Board PCB) PCB

(Heat sink)

PCB RO4350B

THz QWP GN1068 PCB

PCB 0.8 mm SMA PCB

50

THz QWP PCB

GN1068

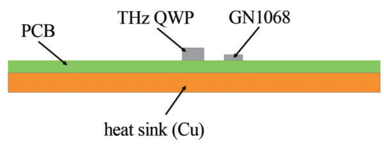

Fig. 2 Packaging diagram of THz QWP and GN1068

2 THz QWP GN1068

2 ÊO¸=ñ4š

THz QWP 10 K GN1068 THz QWP

GN1068

GN1068 THz QWP PCB 2

(Sample holder) 3

GN1068 4 (RF h)

(OUT N OUT P) -

(I U)

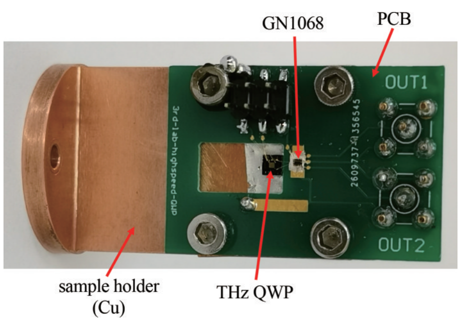

Fig. 3 Photo of the integrated chip of THz QWP and GN1068 installed on a copper sample holder

3 THz QWP

GN1068

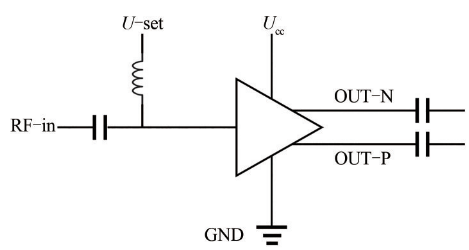

Fig. 4 Schematic of the electrical characteristic measurement of GN1068

4 GN1068

THz THz GN1068 THz QWP THz

THz (THz Quantum Cascade Laser QCL)

(Off Axis Parabolic OAP)

5

OAP THz QCL

THz QWP OAP 90°

THz QWP 4.3 THz[22]

(NEP) pW/Hz$^{1/2}$ 8 K

0.1 A/W 0.1 V THz

QCL [23]

4.3 THz 100 m×2 mm

56 K 2.0 A

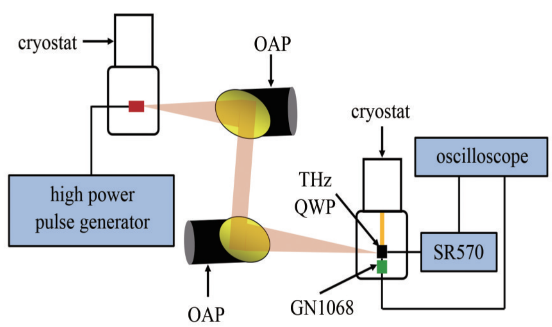

Fig. 5 Optical schematic of verification system for amplifying detection signal of THz QWP under low temperature

5 THz QWP

2 s 10 kHz 0.5 mW THz QCL THz QWP 0.5 m THz QWP GN1068 (SR570) (Oscilloscope)

3 ÊO¸3ÿ È :@Ô@æ

3.1 GN1068*a ’ S6)

4 300 K 8 K GN1068 (Input signal) (U_{cc}) I U

6 GN1068 300 K 8 K U_{cc} I U 6 300 K 8 K GN1068 I U GN1068 GN1068

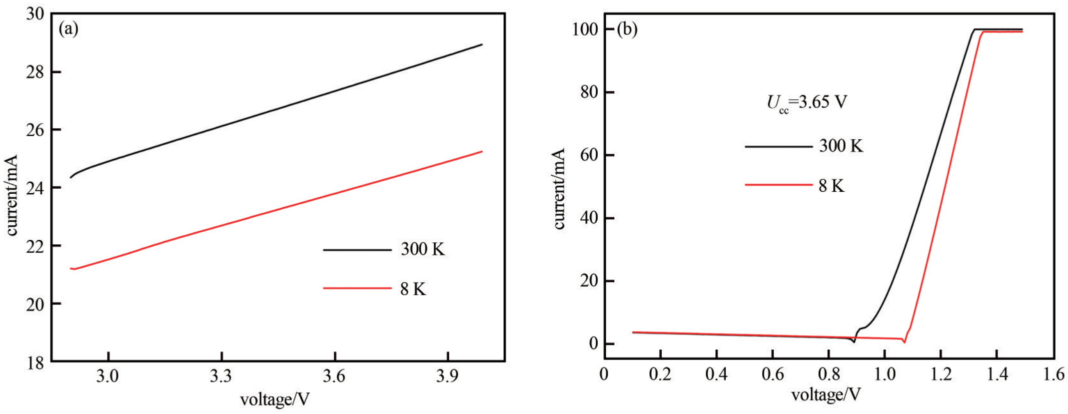

Fig. 6 I-U curves on (a) power supply port (U_{cc}) and (b) signal input port of GN1068 at 300 K and 8 K

6 300 K 8 K GN1068 (a) (U_{cc}) (b) I U

GN1068 7 RF -21 dBm RF GN1068

GN1068 GN1068 -36 dBm 0.1~7.5 GHz U_{cc} 3.65 V 6 0.1~3 GHz

300 K 5 dB 2.5 dB Ge-Si P

[19] GN1068 8 K

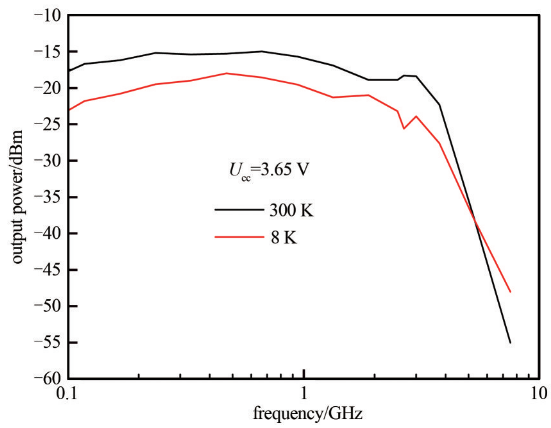

Fig. 7 Gain curves of GN1068 at 300 K and 8 K

7 GN1068 300 K 8 K

3.2 Kò <7Û's z#U j S S6)

GN1068 THz QWP 5 (SR570, 1 mA/V) THz QWP 0.6 V THz QWP 0.6 V×1 mA/V=0.6 mA GN1068 THz QWP GN1068 SR570 THz QWP THz QWP GN1068 OUT-P( ) OUT-N( ) 0 (8) 8 U_{amp}= 336 mV

2 s THz QCL GN1068 THz QWP 0.6 mA/336 mV=1.78 mA/V 560 SR570 1 mA/V GN1068 8 K 1.78 mA/V 560 0.1~3 GHz THz QWP GN1068 10 kHz THz

THz QCL (s) GN1068 100 MHz

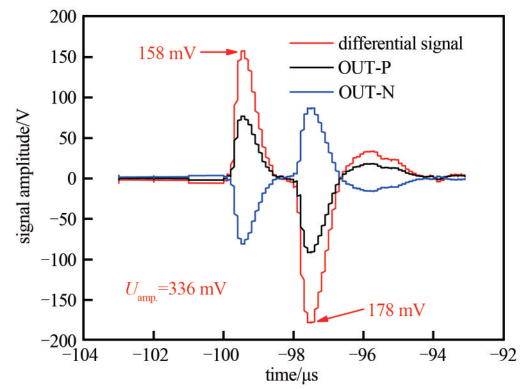

Fig. 8 Differential voltage signal amplified by GN1068 (red curve)

8 GN1068 ( )

4 3ÿ@æ

GN1068 8 K 0.1~3 GHz 5 dB GN1068 THz QWP THz 2 s THz GN1068 THz QWP 8 K GN1068 1.78 mA/V 560 THz THz QCL GN1068 THz

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