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DIAMASIC: A multichannel front-end electronics for high-accuracy time measurements for diamond detectors

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Introduction

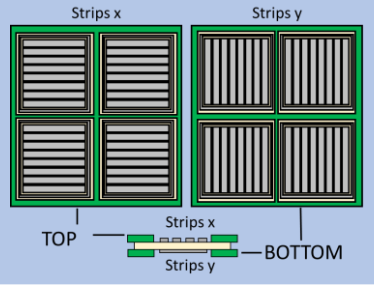
This study describes the design and testing results of an 8 channels preamplifier-discriminator circuit based on a resistive feedback Transimpedance Amplifier architecture and a Leading-Edge Discriminator stage for fast high-accuracy time measurement systems using diamond detectors.

Diamond detector

Chemical Vapor Deposition (CVD) Diamond detector offers an attractive alternative to silicon detector:

Property	Units	Diamond	Silicon
Band Gap E_g	eV	5.47	1.12
Electron mobility μ_e	$cm^2 / V{\cdot}s$	1700	1420
Hole mobility μ_h	$cm^2 / V{\cdot}s$	2100	470
Saturation velocity	cm / s	$2{\times}10^7$	$1.4{\times}10^7$
Intrinsic carrier density	cm^{-3}	$<10^3$	$1.5{\times}10^{10}$
e/h pair energy	eV	13	3.6
Displacement energy	eV	37-47	15-20
Density	g cm^{-3}	3.52	2.33
Rad length X_0	cm	12.2	9.4
Dielectric constant ε_r	(relative)	5.7	11.9
Breakdown E-Field	V/µm	1000	30
Resistivity	Ω/cm	$>10^{15}$	10^5 - 10^6

The CVD diamond detector of this study is a double-side stripped metallized diamond used as a position sensitive detector:

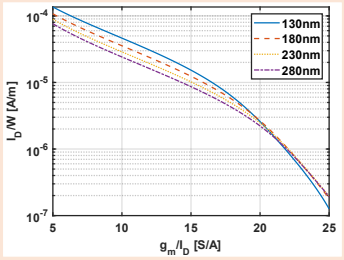


Front-end electronics

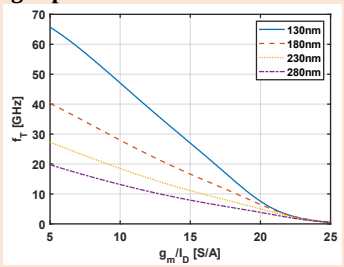
g_m/I_d design methodology

Using the *g_m/I_d* design methodology allows designing circuit that are:

- **low power**

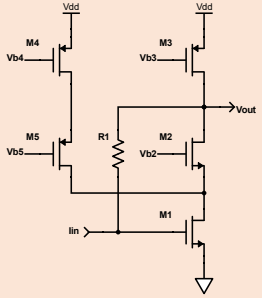


- **high speed**

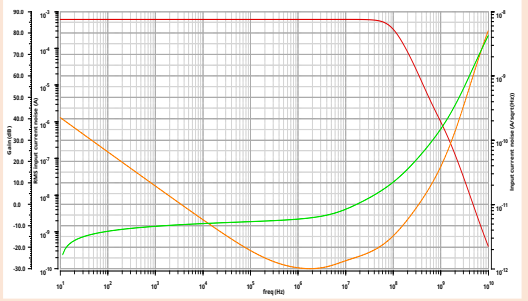


Amplifier topology

The architecture of the resistive feedback TIA

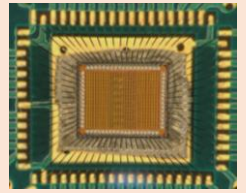


Achieved performances via electrical simulations

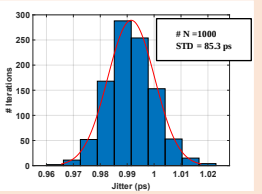


Test results

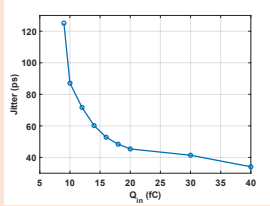
Chip fabricated in a 130 nm CMOS technology



Measured timing jitter for a 10 fC input charge



Measured timing jitter for different input charges



Conclusion

The size of the fabricated chip is 1.27x1.22 mm² and the total power consumption of one channel is about 1.5 mW with a power supply of 1.2 V. Testing results shows a timing jitter of about 80 ps for a 10 fC input charge pulse.