Coordinating Panel for Advanced Detectors of the Division of Particles and Fields of the American Physical Society

CPAD Instrumentation Frontier Workshop 2021

18 - 22 March 2021, Stony Brook, NY, USA

Blue Sky Session

Silicon Carbide:

a new frontier for radiation detectors?

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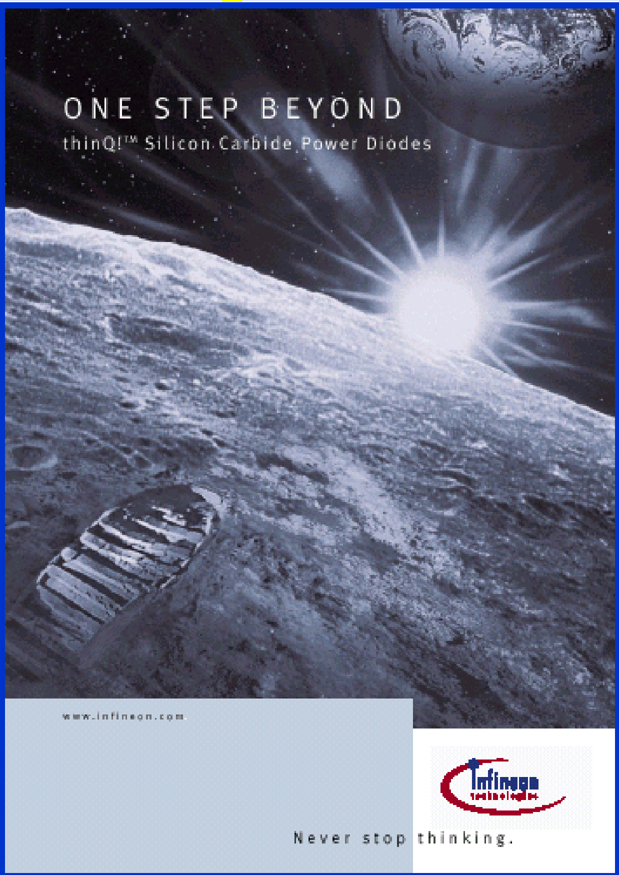
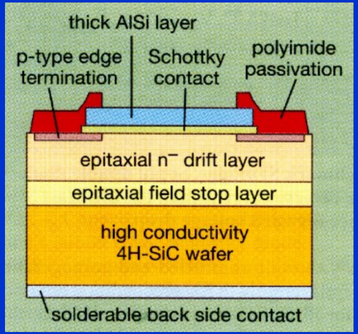
Department of Electronics, Information and Bioengineering
and
National Institute of Nuclear Physics (INFN)
Milan, Italy

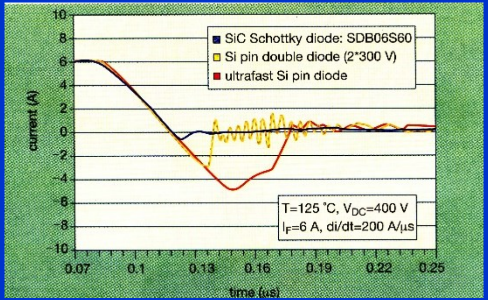
April 2001: first commercial SiC Diode





600 V - 4 A

300 V - 10 A



Applications

Compact Switched Mode Power Supplies

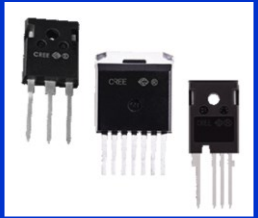
Today industrial SiC devices

Industrial World is already producing and using SiC devices

ST | Wolfspeed. A CREE COMPANY | infineon | ROHM SEMICONDUCTOR | DENSO Crafting the Core | TOYOTA | MITSUBISHI ELECTRIC Changes for the Better

MOSFETs and Diodes

600 V – 1.2 kV, up to 150 A



High efficiency DC/DC Converters, Inverters

Automotive

Reneavable energy

USA R&D for SiC & GaN industrial applications

PowerAmerica

Advancing Silicon Carbide and Gallium Nitride technologies.

PowerAmerica by the numbers

37	18	5	33	$140
INDUSTRY MEMBERS	UNIVERSITY PARTNERS	NATIONAL LABS	INVENTION DISCLOSURES FILED	MILLION IN PROJECT FUNDING

PowerAmerica

Advancing Silicon Carbide and Gallium Nitride technologies.

https://poweramericainstitute.org

Resources | Membership | Education and Workforce Development | Funding Opportunities | Events | Latest News

Accelerating the next generation of power electronics.

SiC Detector R&D in Italy

Reactor Engineering epi-SiC growth

Material Characterization

Detector / FEE design & fabrication

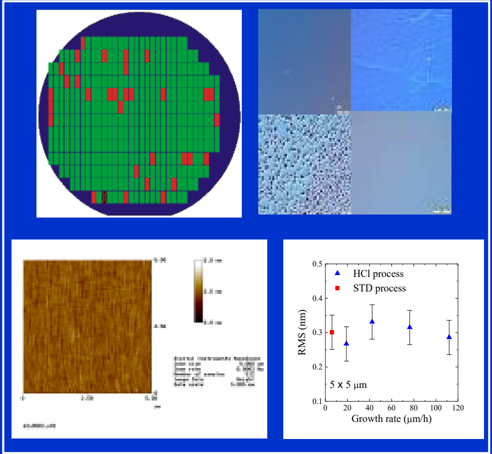
Detector / FEE characterization

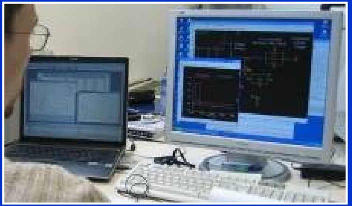
Univ. Bologna, Catania, Univ. Modena, Torino

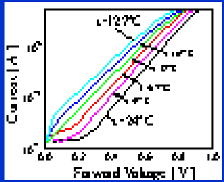
Politecnico di Milano, Univ. Catania

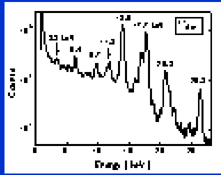
SELEX Sistemi Integrati

Politecnico di Milano, Univ. Modena, Catania, Torino



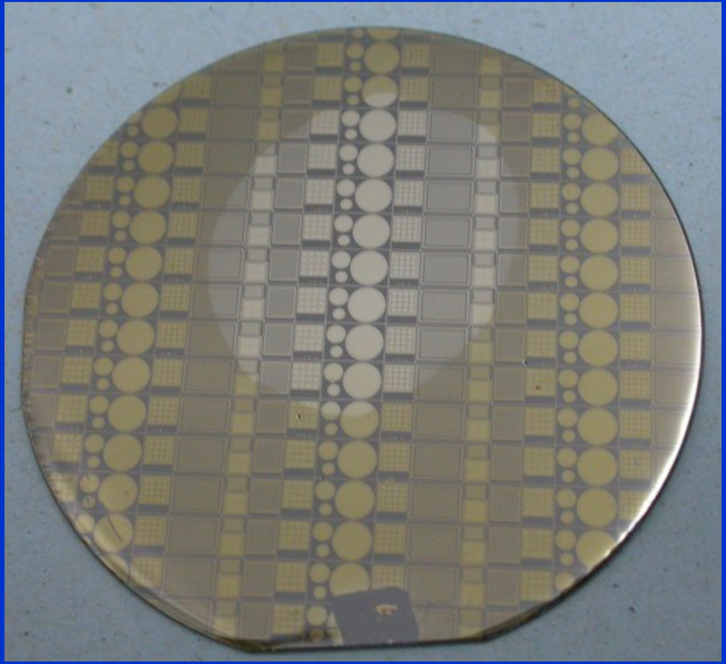




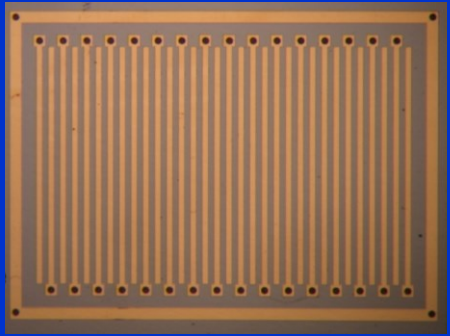


SiC detector prototypes

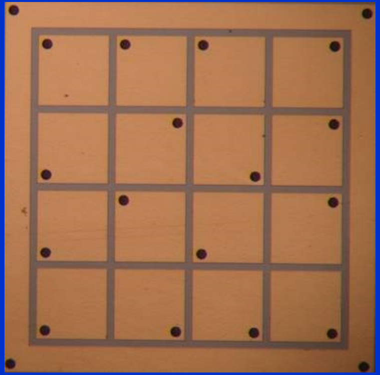
Processed SiC Wafer

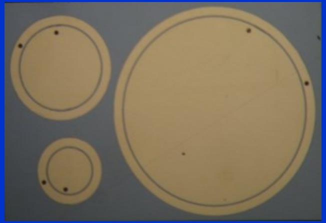


Microstrip

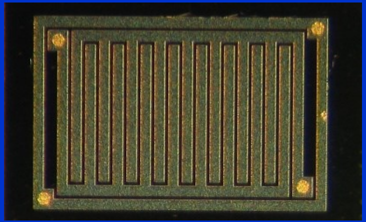


Pixel

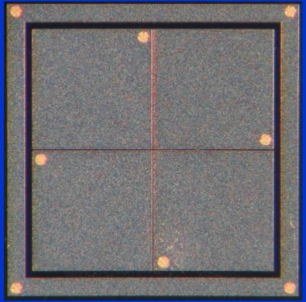




Pad



Interdigitated

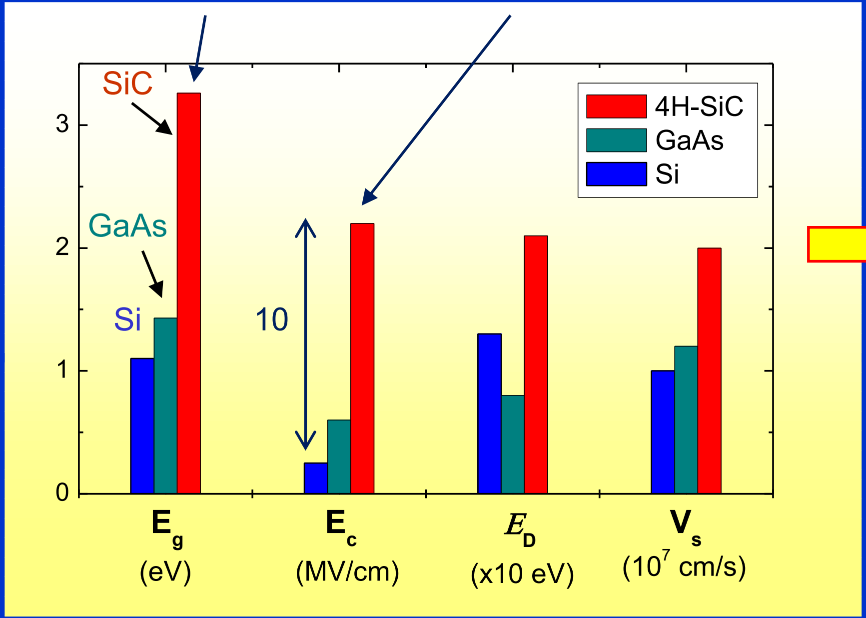


Quad

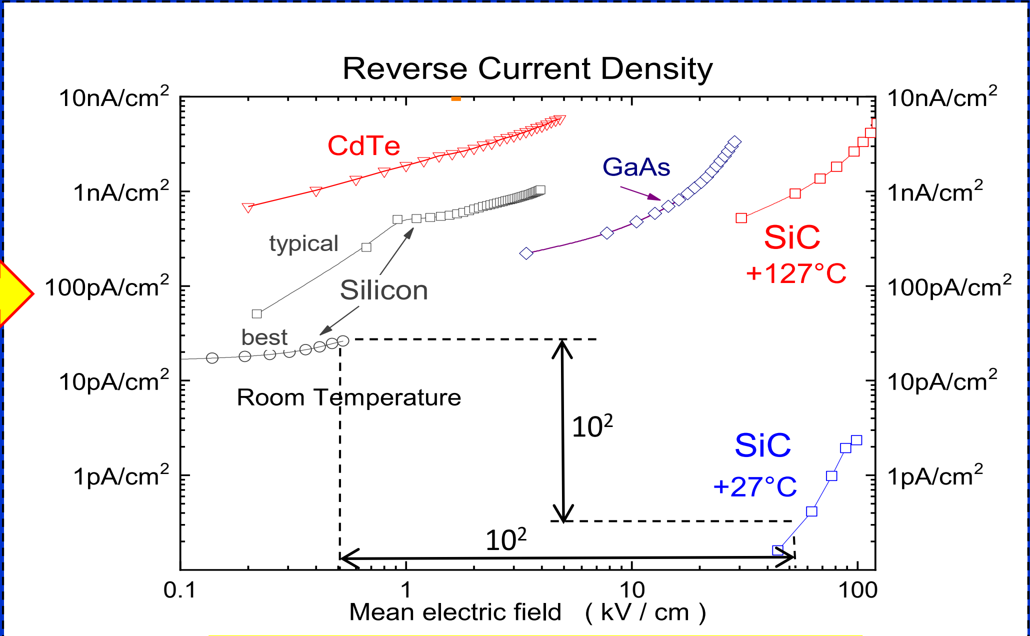
Strength of SiC for Radiation Detection

Wide Bandgap
3.2 eV

High Critical Field
(2 MV/cm)



Experimental Data



J = 1 pA/cm^2 @ +27°C → sub-electron ENC

J = 1 nA/cm^2 @ +127°C → High-T operation

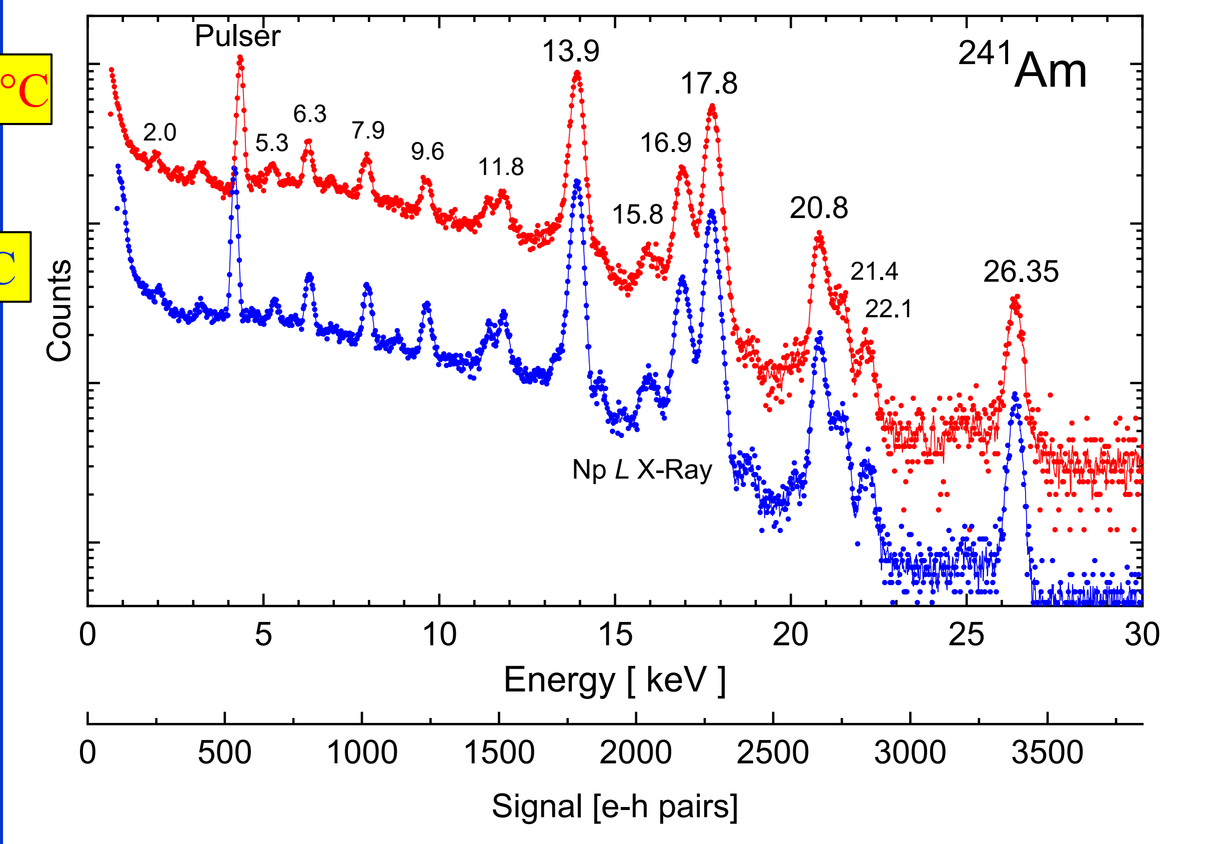
E=100 kV/cm → very fast, no charge trapping

High Resolution X-Ray Spectroscopy with SiC pixel

FWHM

177 eV
(9.6 e⁻ rms) **+100 °C**

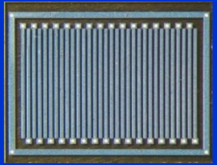
120 eV
(6.5 e⁻ rms) **+28 °C**

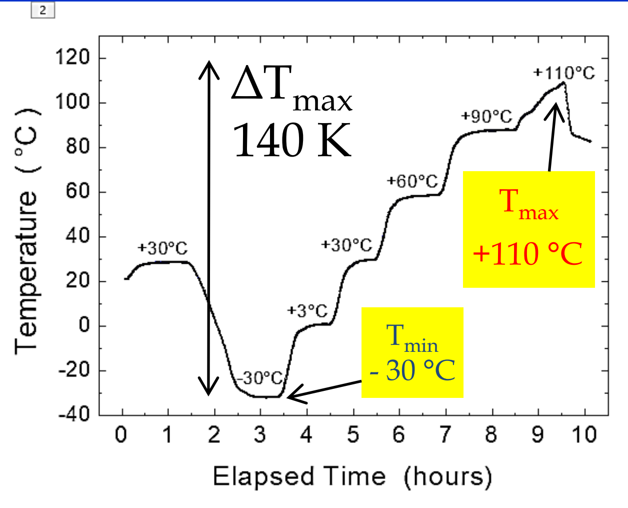


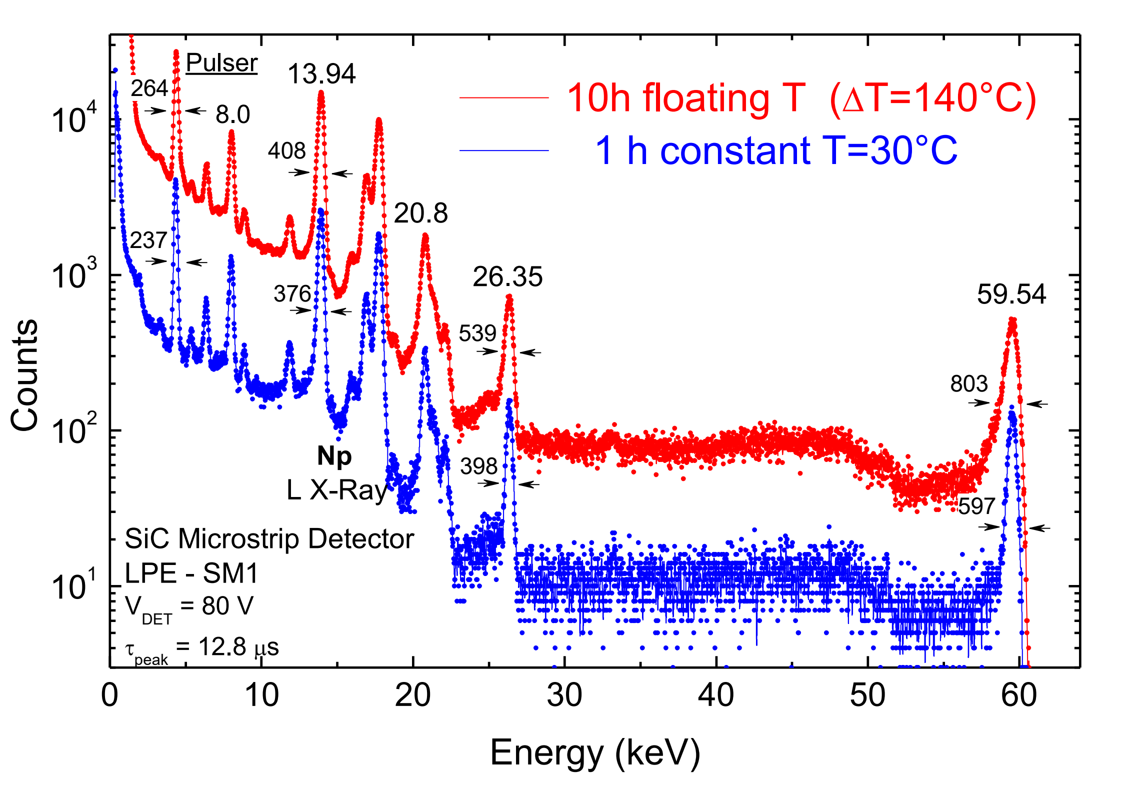
SiC detector under floating temperature

Bandgap energy (e-h pair creation energy) : minimum temperature coefficient

SiC microstrip detector

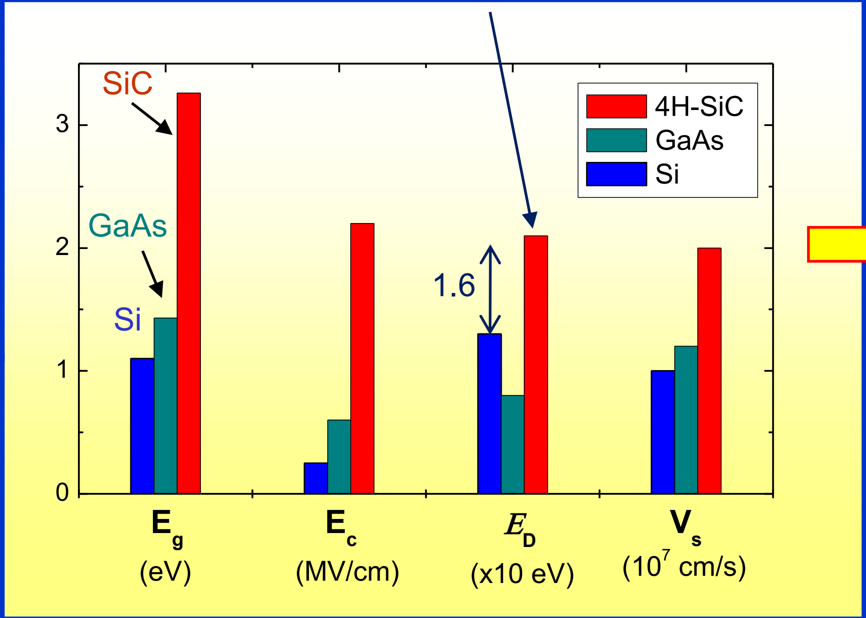




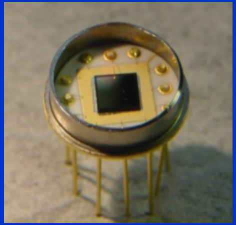


Strength of SiC for Radiation Detection

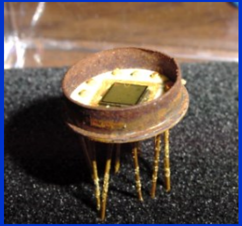
High Atom Displacement Energy
(22 / 35 eV)



Experimental Data

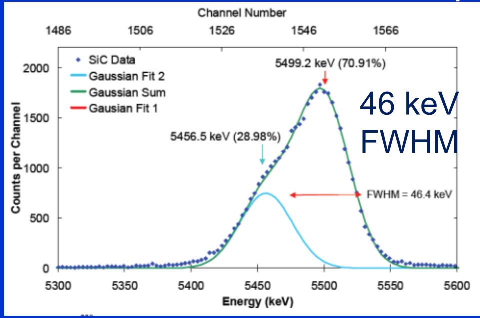


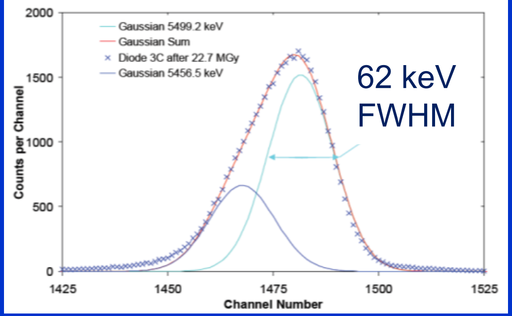
Before irradiation



After 23 MGy of ^{137}Cs

^{238}Pu alpha spectra

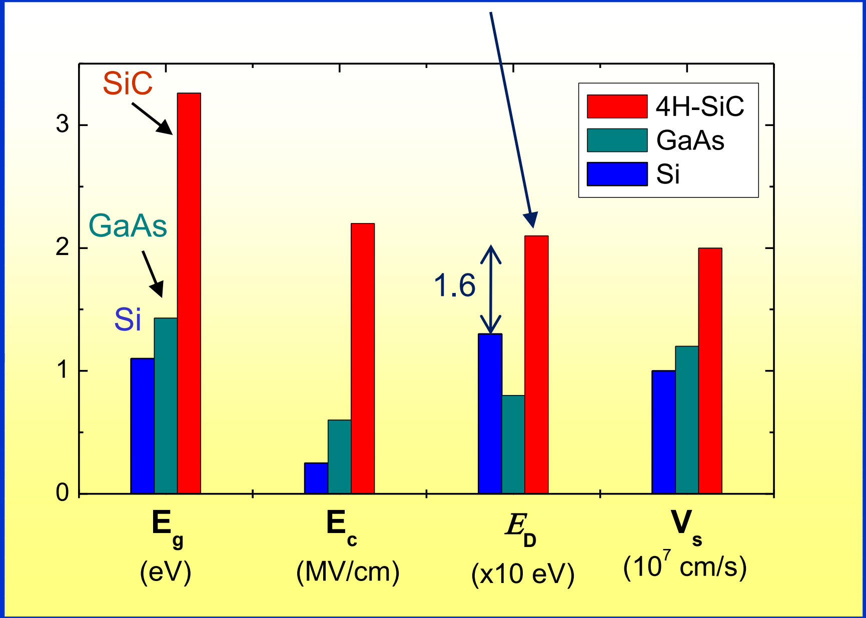




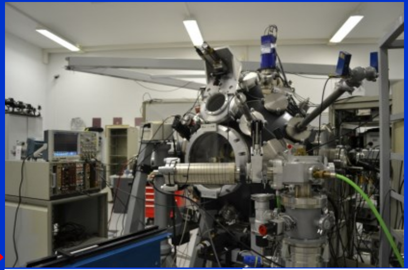
Courtesy of F. H. Ruddy, Westinghouse

Strength of SiC for Radiation Detection

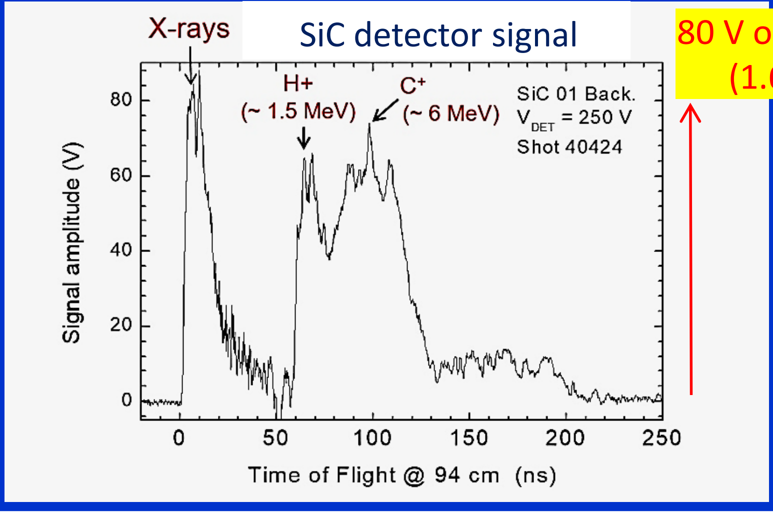
High Atom Displacement Energy
(22 / 35 eV)



Experimental Data
Plasma radiation



Asterix – PALS (Prague)
High Power Laser
3 TW / 1 J / 350 ps Laser

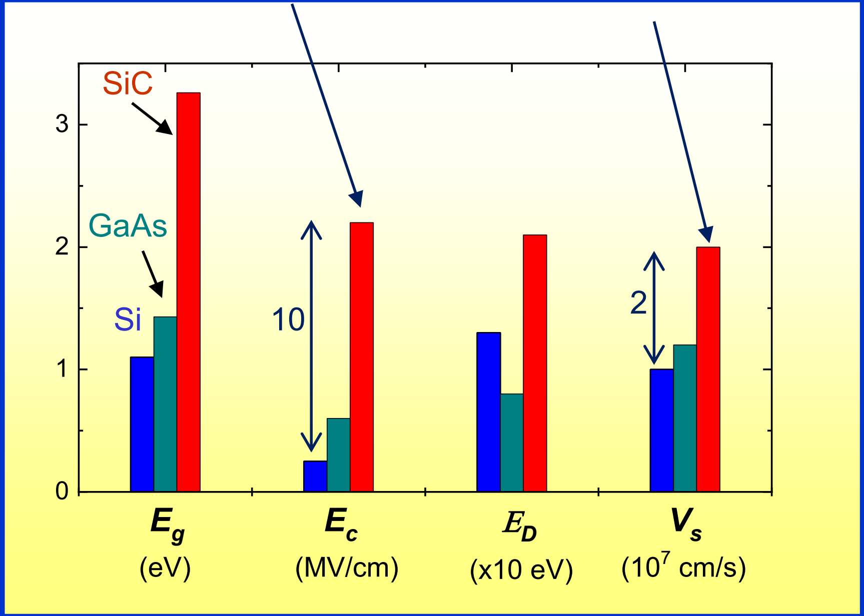


80 V on 50 Ω
(1.6 A)

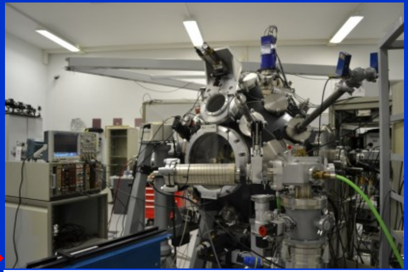
Strength of SiC for Radiation Detection

High Critical Field
(2 MV/cm)

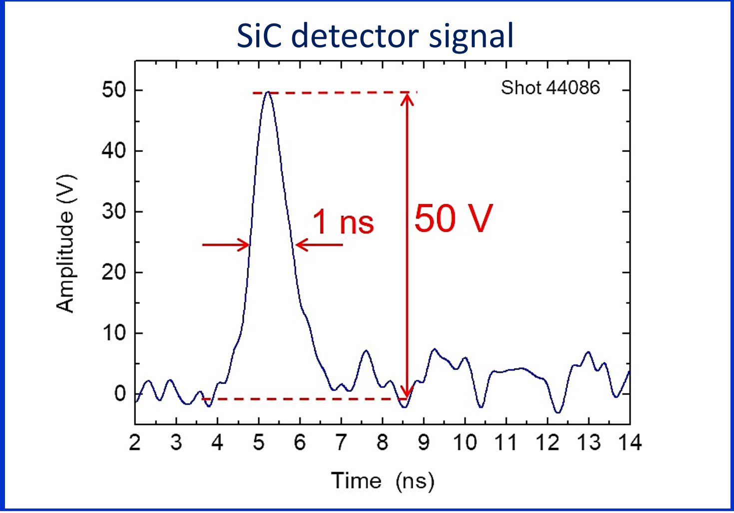
High Saturation Velocity
(200 µm/ns)



Experimental Data
Plasma radiation



Asterix – PALS (Prague)
High Power Laser
3 TW / 1 J / 350 ps Laser



SiC detectors: a wide and successfull R&D

Plasma

Silicon carbide detector for laser-generated plasma radiation

Giuseppe Bertuccio[a,b,*], Donatella Puglisi[a,b], Lorenzo Torrisi[c,d], Claudio Lanzieri[e]

[a] Department of Electronics Engineering and Information Science, Politecnico di Milano, Como Campus, Via Anzani 42, 22100 Como, Italy
[b] National Institute of Nuclear Physics, INFN sez. Milano, Via Celoria 16, 20133 Milano, Italy

Alpha

High-Resolution Alpha-Particle Spectrometry Using 4H Silicon Carbide Semiconductor Detectors

Frank H. Ruddy, John G. Seidel, Haoqian Chen, Abdul R. Dulloo, *Member, IEEE*, and Sei-Hyung Ryu, *Member, IEEE*

γ-ray, neutrons

Simultaneous Measurement of Neutron and Gamma-Ray Radiation Levels from a TRIGA Reactor Core Using Silicon Carbide Semiconductor Detectors

A.R. Dulloo[1*], F.H. Ruddy[1], J.G. Seidel[1], C. Davison[2], T. Flinchbaugh[2] and T. Daubenspeck[2]
[1]Westinghouse Science & Technology Center, 1310 Beulah Road, Pittsburgh, Pennsylvania 15235

Electrons, protons

Radiation tolerance of epitaxial silicon carbide detectors for electrons, protons and gamma-rays

F. Nava[a,*], E. Vittone[b], P. Vanni[c], G. Verzellesi[d], P.G. Fuochi[e], C. Lanzieri[f], M. Glaser[g]

MIP

Particle detectors based on semi-insulating Silicon Carbide

M. Rogalla*, K. Runge, A. Söldner-Rembold

University of Freiburg, Hermann-Herder-Str. 3, 79104 Freiburg, Germany

X-ray

A new generation of X-ray detectors based on silicon carbide

Giuseppe Bertuccio[a,*], Roberto Casiraghi[a], Antonio Cetronio[b], Claudio Lanzieri[b], Filippo Nava[c]

[a] *Department of Electronics Engineering and Information Science, Politecnico di Milano, P.za L. da Vinci 32, Milano 20133, Italy*

UV

Demonstration of 4H-SiC visible-blind EUV and UV detector with large detection area

X. Xin, F. Yan, T.W. Koeth, C. Joseph, J. Hu, J. Wu and J.H. Zhao

What next?

Large format detectors R&D

What is needed now?

A significant application

Additional information:
see presentation at CPAD Solid State Session
Thursday, 18 March 2021
giuseppe.bertuccio@polimi.it