Characterization of SunSILICON and SunSILICON P Detectors for Photon and Electron Dosimetry in Radiation Therapy

Andreas A. Schönfeld[1], Mohamad Ahmad Alissa[2], Olivier Evrard[3], Jeff Hildreth[1], Andy Murray[1], David Towle[1], Carson Brame[1], Ann-Britt Schönfeld[1], Charbel A. Habib[4], Gerhard Wessing[5] and Damian Czarnecki[6]

(1) Sun Nuclear Corp., Melbourne, FL
(2) CDT-West - Centrum für Diagnostik und Therapie, Cologne, Germany
(3) Mirion Technologies, Olen, Belgium
(4) MyMichigan Health, Midland, MI
(5) Radiologie Vechta, Vechta, Germany
(6) Technische Hochschule Mittelhessen, Gießen, Germany

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ABSTRACT

Purpose: The study characterizes SunSILICON and SunSILICON P detectors for photon and electron dosimetry in radiation therapy.

Methods: The detectors were tested in lateral beam profiles and percent depth dose (PDD) profile measurements using motorized water phantoms at various linear accelerators with and without flattening filters and compared to several other detectors as reference.

Results: Photon and electron beam measurements showed excellent agreement with reference detectors.

Conclusion: The study demonstrates that SunSILICON and SunSILICON P detectors are ideal for accurate dosimetry in radiation therapy, covering the full range of relative dosimetry measurements.

CONTACT

Dr. Andreas Schönfeld
Sun Nuclear Corp.
3275 Suntree Blvd, Melbourne, FL 32940
aschoenfeld@mirion.com

INTRODUCTION

This study characterizes Sun Nuclear's two novel silicon diode detectors, the unshielded silicon diode detector SunSILICON (Model 1048) and the shielded silicon diode detector SunSILICON P (Model 1049) in relative photon and electron dosimetry.

METHODS AND MATERIALS

1048 SunSILICON (unshielded) and 1049 SunSILICON P (shielded) silicon diode detectors were characterized experimentally in lateral beam profile and percent depth dose (PDD) profile measurements using motorized water phantoms at various linear accelerators with and without flattening filter. Nominal photon energies ranged from 4 MV to 25 MV and nominal electron energies from 6 MeV to 22 MeV. The 1048 SunSILICON was investigated in square photon fields from 0.4 cm to 10 cm and square electron fields from 6 cm to 25 cm. 1049 SunSILICON P was investigated in square photon fields from 1 cm to 40 cm. PDDs were measured to a depth of 30 cm. SunDOSE was used for a 1D gamma index analysis (1 %, 0.5 mm, threshold 0% to include full tails) to compare profile measurements against those of suitable reference detectors.

RESULTS

Figures 1 – 8 present representative examples of PDDs and lateral beam profiles measured with 1048 SunSILICON and 1049 SunSILICON P in comparison with other detectors. Tables 1 – 3 present median gamma pass rates for all compared profiles.

Table 1. Median 1D gamma pass rates γ (1%, 0.5 mm, TH = 0%) and standard deviations σ for a number of scans (#) measured with **1048 SunSILICON in photon beams** of 4 MV to 25 MV.

Comparison to	Type	Field Sizes	# Scans	γ	σ
microDiamond	Profiles	0.5 cm – 10 cm	23	96.5	4.9
SNC125c	profiles	4 cm – 10 cm	14	92.9	9.7
microSilicon	Profiles	0.5 cm – 40 cm	38	100	2.0
microDiamond	PDDs	2 cm – 10 cm	20	98.3	4.0
SNC125c	PDDs	4 cm – 10 cm	20	99.0	1.4
microSilicon	PDDs	0.8 cm – 40 cm	34	100	0.0

Table 2. Median 1D gamma pass rates γ (1%, 0.5 mm, TH = 0%), standard deviations for a number of scans (#) measured with **1048 SunSILICON in electron beams** of 6 MeV to 22 MeV.

Comparison to	Type	Field Sizes	# Scans	γ	σ
SNC125c	Profiles	6 cm to 25 cm	24	89.8	5.5
microSilicon	Profiles	6 cm to 25 cm	27	100	0.7
SNC350p	PDDs	10 cm	9	92.8	4.3
microSilicon	PDDs	6 cm to 25 cm	32	100	0.2

Table 3. Median 1D gamma pass rates γ (1%, 0.5 mm, TH = 0%) and standard deviations σ for a number of scans (#) measured with **1049 SunSILICON P in photon beams** of 4 MV to 25 MV.

Comparison to	Type	Field Sizes	# Scans	γ	σ
microDiamond	Profiles	1 cm to 40 cm	20	92.7	11
microSilicon X	Profiles	0.5 cm to 40 cm	44	100	0.5
SNC125c	Profiles	4 cm to 40 cm	22	86.2	6.2
microDiamond	PDDs	2 cm to 10 cm	14	94.8	2.6
microSilicon X	PDDs	2 cm to 40 cm	27	99.8	1.6
SNC125c	PDDs	4 cm to 40 cm	24	99.0	1.5

DISCUSSION

Photon beam profiles measured with 1048 SunSILICON showed excellent agreement with PTW's microDiamond and microSilicon (Table 1 and Figure 1). Passing rates against SNC125c were slightly lower due to the chamber's volume averaging effect. Photon PDDs measured with 1048 SunSILICON were indistinguishable from those measured with SNC125, microDiamond or microSilicon (Table 1 and Figure 2).

Electron beam measurements conducted with 1048 SunSILICON matched those of microSilicon and showed good agreement with ion chamber measurements (Figures 3 – 4 and Table 2).

Photon beam profiles measured with 1049 SunSILICON P showed excellent agreement with PTW's microDiamond and microSilicon X (Table 3 and Figures 5, 7 and 8). Passing rates against SNC125c were slightly lower due to the chamber's volume averaging effect. Photon PDDs measured with 1049 SunSILICON P were indistinguishable from those measured with SNC125, microDiamond or microSilicon X (Table 3 and Figure 6).

CONCLUSIONS

SunSILICON and SunSILICON P excel in their respective applications. As a pair, they cover the full range of relative dosimetry measurements conducted in radiation therapy.

SunSILICON

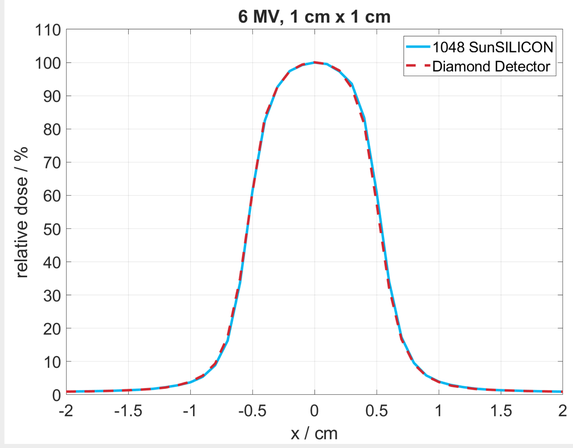

Figure 1: Lateral beam profile of a 1 cm x 1 cm, 6 MV photon field. Measurements were conducted with 1048 SunSILICON and PTW's microDiamond detector.

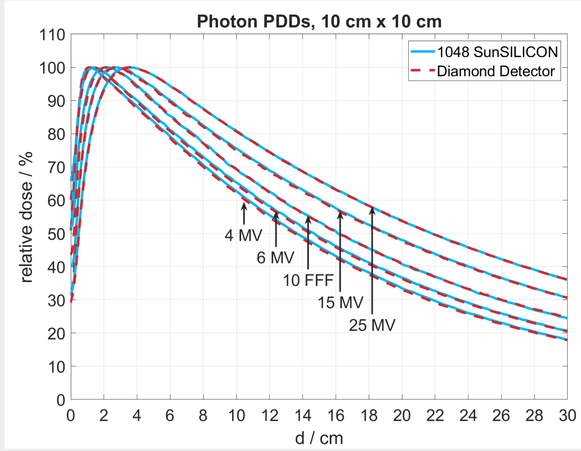

Figure 2: Percentage Depth Dose distributions of 10 cm x 10 cm photon fields measured at various beam energies. Measurements were conducted with 1048 SunSILICON and PTW's microDiamond detector.

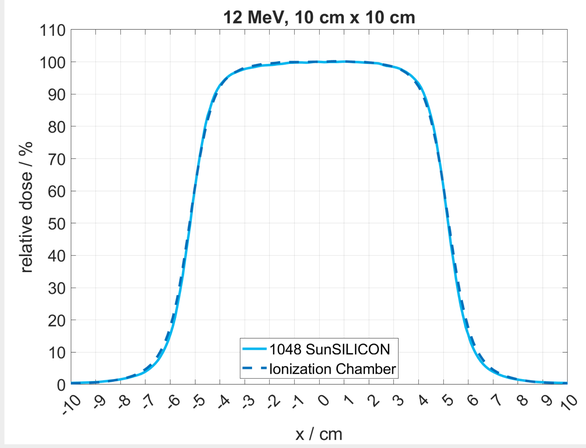

Figure 3: Lateral beam profile of a 10 cm x 10 cm, 12 MeV electron field. Measurements were conducted with 1048 SunSILICON and 1041 SNC125c.

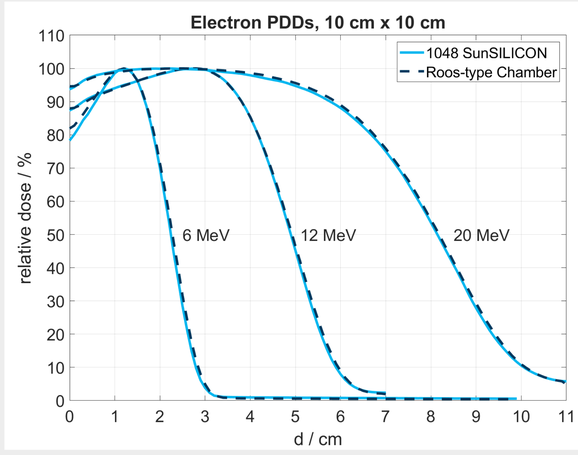

Figure 4: Percentage Depth Dose distributions of 10 cm x 10 cm electron fields measured at various beam energies. Measurements were conducted with 1048 SunSILICON and 1045 SNC350p.

SunSILICON P

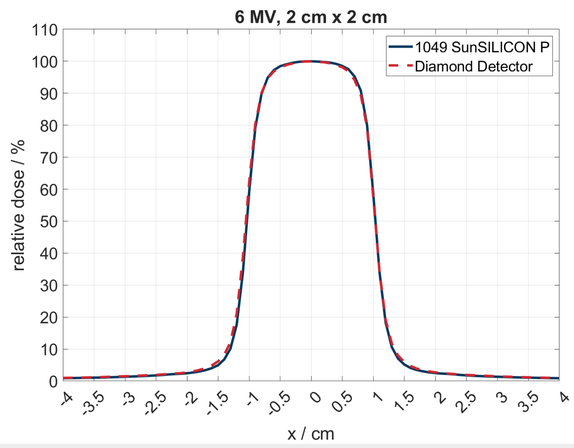

Figure 5: Lateral beam profile of a 2 cm x 2 cm, 6 MV photon field. Measurements were conducted with 1049 SunSILICON P and PTW's microDiamond detector.

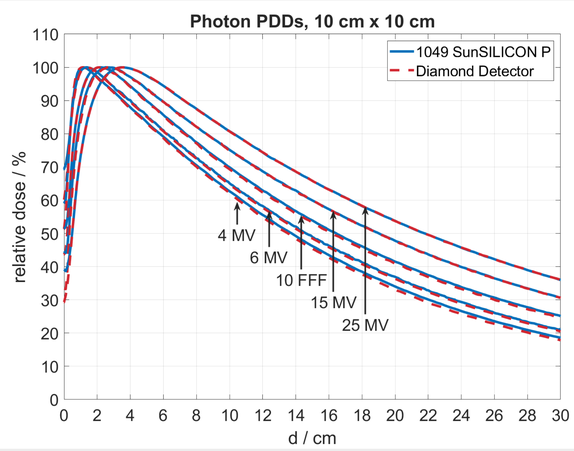

Figure 6: Percentage Depth Dose distributions of 10 cm x 10 cm photon fields measured at various beam energies. Measurements were conducted with 1049 SunSILICON P and PTW's microDiamond detector.

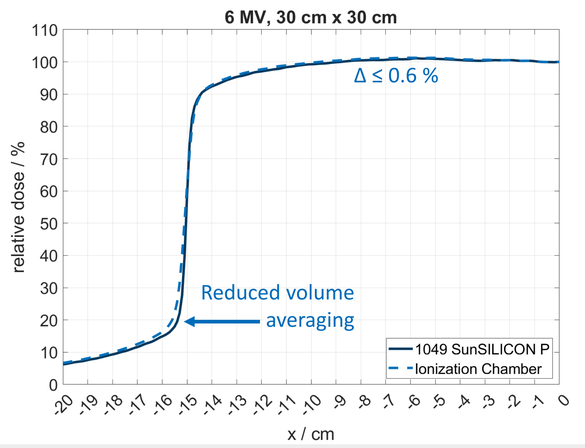

Figure 7: Lateral beam profile of a 30 cm x 30 cm, 6 MV photon field. Measurements were conducted with 1049 SunSILICON P and 1041 SNC125c.

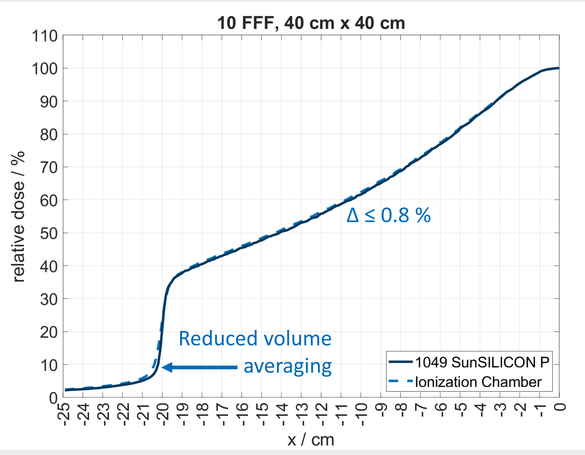

Figure 8: Lateral beam profile of a 40 cm x 40 cm, 10 FFF photon field. Measurements were conducted with 1049 SunSILICON P and 1041 SNC125c.