ELECTROGENICS LABS

AUSTRALIAN TECHNOLOGIES COMPETITION WINNER 2020

ELECTROGENICS LABORATORIES LTD

(ACN 635 525 745)

AIP AUSTRALIAN INSTITUTE OF PHYSICS

The future of Semiconductors

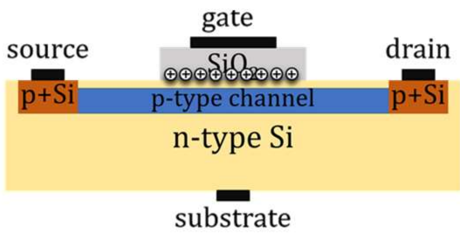
MOSkin™

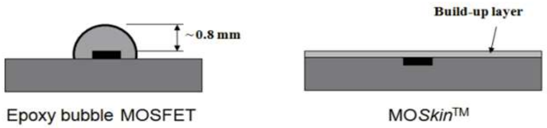
Custom in-vivo radiation dosimetry

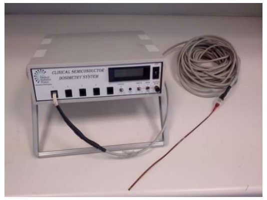
31 Oct 2023

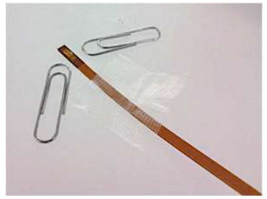
Background

- MO*Skin*™ is a real time solid state radiation dosimeter developed by Prof. Rosenfeld and his team at the Centre for Medical Radiation Physics at University of Wollongong
- Custom radiation sensitive p-channel MOSFET with novel packaging technology
- Patented in 80% of global markets
- Successful trials conducted at >20 International and Australian based Radiation Oncology Hospitals.
- Electrogenics Laboratories Ltd (ELL) negotiated an exclusive license to commercialise the technology









Intellectual Property

Patents

APPLIED COUNTRY	TITLE OF INTELLECTUAL PROPERTY	PATENT NUMBER	FILING DATE	GRANT DATE	EXPIRY DATE
US	“Radiation Sensor and Dosimeter”	12/602,195; US8742357 (B2)	2 June 2008	3 June 2014	12 September 2031
China	“Radiation Sensor and Dosimeter”	CN101730853(A) CN101730853 (B)	2 June 2008	5 December 2012	2 June 2028
Europe	“Radiation Sensor and Dosimeter”	EP2150839(A1) EP2150839 (A4)	2 June 2008	5 August 2020	2 June 2028
International	“Radiation Sensor and Dosimeter”	WO2008148150 (A1) titled	2 June 2008	Filed	

- 2 key claims
  - A radiation sensor, comprising:
    a carrier material mountable to a substrate; and a semiconductor detector mounted to said carrier material;
    wherein a radiation sensitive portion of said semiconductor detector is oriented towards said carrier material and generally away from said substrate, and said carrier material is adapted to transmit radiation to said radiation sensitive portion of said semiconductor detector.
  - A method for thermo-stabilizing a semiconductor detector, comprising correcting threshold voltage drift arising owing to temperature changes according to the forward drop voltage of the source-substrate p-n junction

- In layman terms
  - **Sensor mounted upside down such that radiation passes through the polyimide (Accurate skin depth)**
  - **Correcting for temperature drift using the actual MOSFET (no need for additional temp compensation component on sensor)**

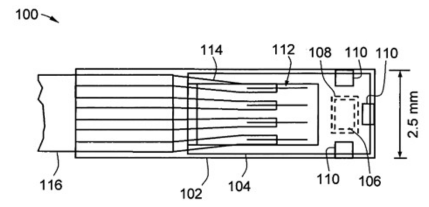
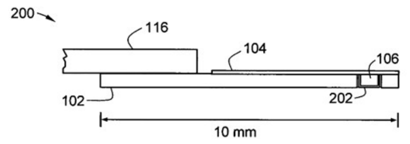


Figure 1



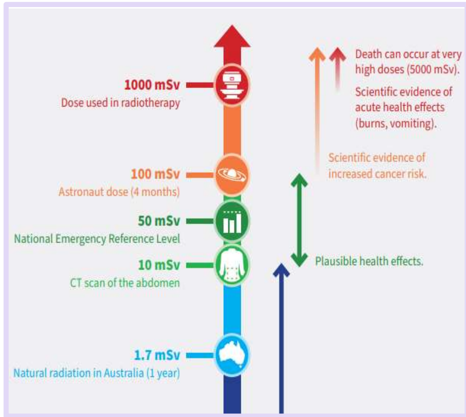
MOS*kin*™ Technology Tested and Proven

- MOS*kin*™ has been **tested and validated** in Australia and internationally in >20 hospitals and clinics
- Tested on over 2,000 patients and simulations
- Over 40 published scientific papers
- A subject of 21 PhDs
- Over **$10 million** in equity, cash and grants invested to date
- St George Public Radiation Oncology unit has been using the Company's prototypes under ethics committee approval for over 12 months, recently expressing interest to extend the use of prototypes in preference to existing in market technology

INTERNATIONAL	AUSTRALIA
Argon National Lab, USA	St George Cancer Care Centre, Prostate Cancer Institute, St George Hospital, Sydney
Mass General, Boston, USA	St Vincents Hospital, Sydney
Wisconsin University Hospital, USA	Liverpool Hospital
Brookhaven National Lab, USA	Calvary Mater Hospital – Newcastle, Australia
University of Malaya Medical Centre, Kuala Lumpur, Malaysia	Royal Adelaide Hospital
Italian National Institute of Tumours, Milan, Italy	Illawarra Cancer Care Centre
CERN Switzerland	Perth Hospital
KEK Japan	Prince of Wales Hospital
Sun Yat-Sen University Cancer Centre, Guangzhou China	Mater Hospital, Newcastle
Radiation Dosimetry Lab, Federal University of Pernambuco, Brazil	Peter MacCallum Cancer Centre
City University Hong Kong Hospital	Geneva Hospital

Why It's CRITICAL To Monitor Medical Radiation Dose?

- Radiotherapy is recommended for over 50% of all cancer patients
  - Unwanted collateral organ or tissue damage is difficult to avoid
  - Human error was identified as the primary cause of reported incidents (ARPANSA Report 2018)
    - manual calculations,
    - time pressures, and
    - following procedures or treatment plans.
  - Overdosing or underdosing can lead to the reoccurrence of tumours or the development of secondary tumours
  - Flash therapy increases risks of unintended collateral damage
- CT scans and Interventional Radiology -
  - Up to equivalent of 200 chest X-rays



Existing Dosimeters have many weaknesses

- Very difficult and time consuming to calibrate and use (1-2hrs)
- Do not all provide real time / immediate feedback of delivered dose (e.g., Thermo-luminescent detectors (TLDs) > 1.5hrs)
- Do not measure the skin dose at the international recommended standard (Water Equivalent Depth (WED) = 0.07mm)
- Are not single use and therefore need to be cleaned / disinfected
- Are not radio transparent - blocking Clinicians vision
- Are expensive & highly cumbersome for routine use

… Limiting LINAC patient throughput, leading to reduced efficiency, increased wait times and suboptimal outcomes.

Existing OLD Technologies

Diodes

TLDs

OSLDs

MOSFETs

Dosimetry use is global & limited by time, complexity & costs

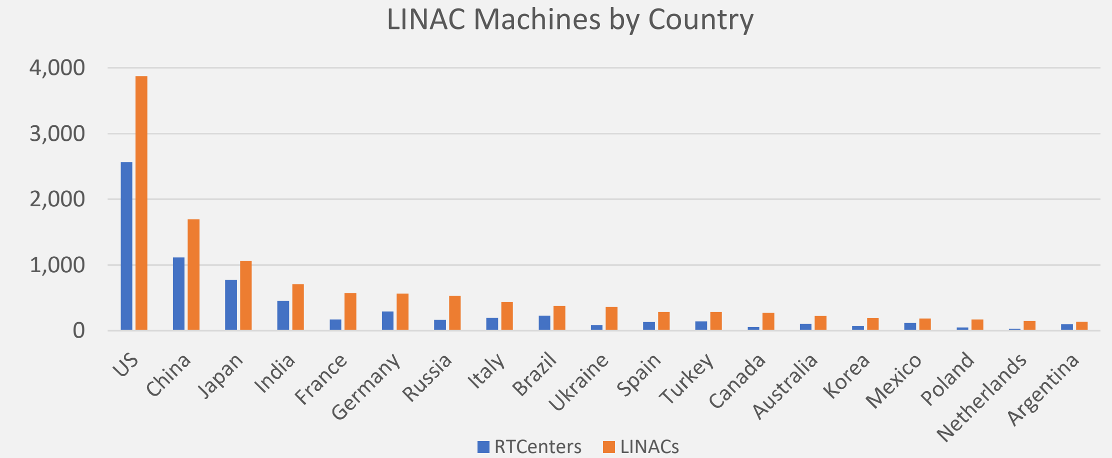
Global radiotherapy customers

8,000 Radiotherapy Centres
with 15,000 + Linear Accelerators (LINACs)

Example dosimeter usage

USA
- 9% of radiotherapy patients
- Key drivers
  - Safety in complex cases
  - ~US$150 reimbursement
  - ~US$1000 special physics consult

France
- 19% of radiotherapy patients
- Key drivers
  - Mandated in regulation



- Existing technologies have not materially changed in many years, wherein the use of dosimetry is therefore influenced and inhibited by the complexity, costs, and inadequacies of existing technologies.
- Because application of dosimetry is swayed by outdated wisdom and knowledge of old existing technologies, usage is stymied.
- ELL tenders its product is so cost and time effective, more accurate, with better clinical pathways … its introduction will increase usage.

Large Untapped Target Markets

Cancer Patients
Radio Oncology Therapy

- **20M** Global Cancer Patients per year
- **10M** Patients where radio oncology therapy indicated
- **6M** Patients with radio oncology therapy (avg. 15 fractions)
- **=90M** Treatments delivered per year

Dosimeters/year potential market
(3 dosimeters average per procedure)

TAM = 270M sensors

Interventional Radiology
Procedures

- **40M+** Interventional Radiology procedures performed globally per annum, including
  - Neuro Angiography
  - Cardio Angiography
  - Venous Conditions
  - Interventional oncology

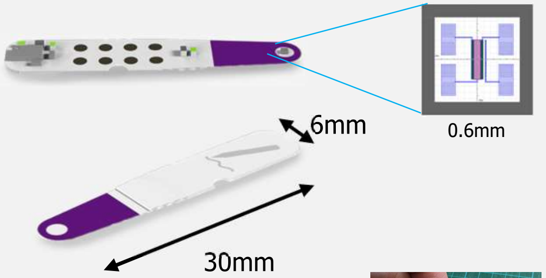
Dosimeters per year potential market (3 dosimeters average per procedure)

TAM = 120M sensors

Total Available Market (TAM) is ~ 390M Sensors per year

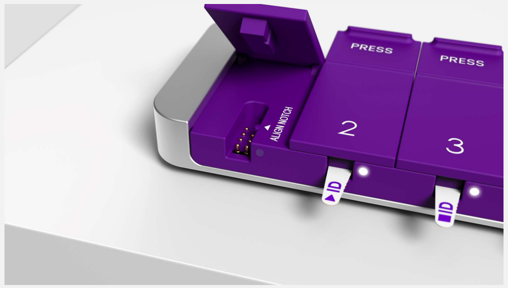
Introducing the MO*Skin*™ system

MO*Skin*™ Sensors



Reusable build-ups

MO*Skin*™ Hub



MO*Skin*™ Reader

Introducing the MO*Skin*™ system

Existing Systems

Linac

Sensors

Reader

Oven

Calculation of results

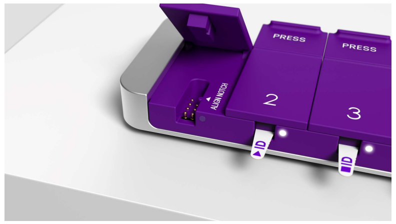
At Linac

Back at the Medical Physics Lab

MO*Skin*™ System

Linac

Sensors



Reader

Software on iPad

Results @ Linac

All performed @ Linac

Materially improving commercial & clinical pathways

	$ Capital Outlay	$ Service cost~10yrs	$ Cost for Sensors^	Prep time before Dose	Time to results	Max Patients /day/Linac #	Typical Accuracy	Application Coverage	Realtime	WED Std
Existing Technology **TLD Sensors**	$50-$250K	$370K	$30-$60	2.4 hrs	>1.5 hrs	5~10	70~80%	~80%	NO	NO
Existing Technology **DIODES** ★	$15- $75K	$112K	$1.5-$2.5K	1 hr	Real Time	12~15	75~85%	~70%	YES	NO
MOSkin™	$7K	$20K	$35	3 mins*	Real time / Instant	20~25	95%+	99%+	YES	YES

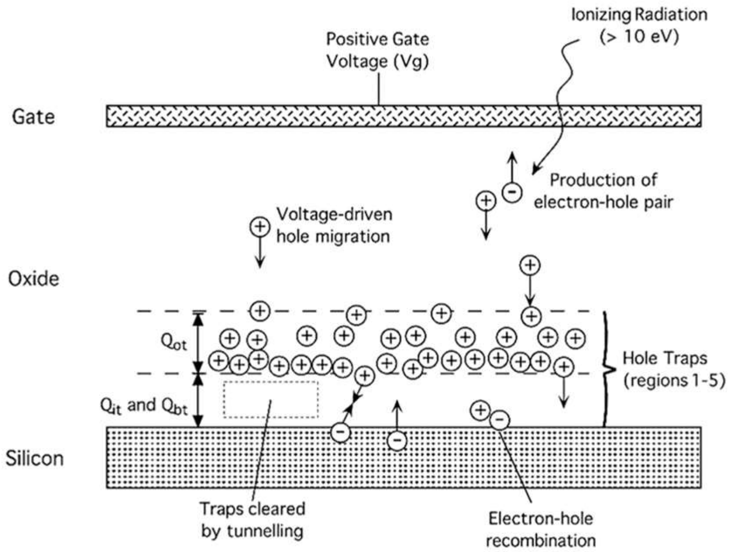
^ Per Sensor. Sensors can be used multiple fractions for same patient

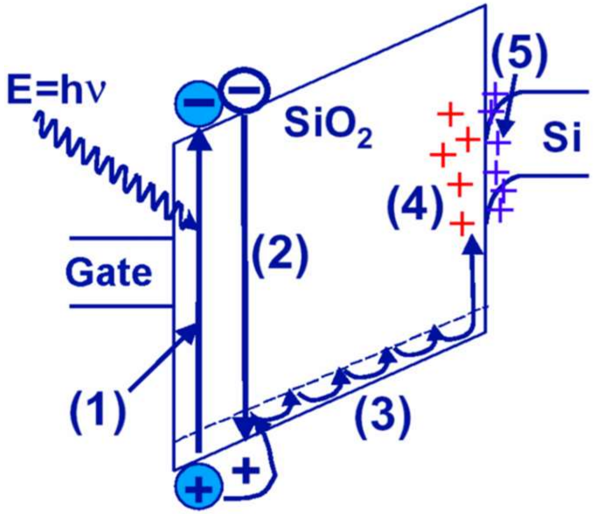
* Assumes pre-calibrated

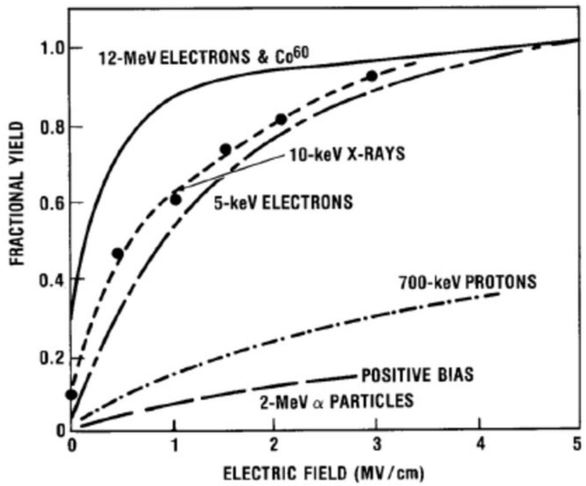
Linac = Linear accelerator, uses electricity to generate high energy beams of electrons

RadFET sensor for total ionizing dose (TID) monitoring

Illustration of main process in TID damage







(1)e-/h+pair generation;
(2)e-/h+pair recombination;
(3)e-/ h+ transport;
(4)hole trapping;
(5)Interface states build-up

- Fractional yield (f_E)of holes depends on E-field in SiO_2 and track density (LET) produced by particle
- The same TID (Si) delivered by different radiation lead to different holes yield

M.R. Shaneyfelt et al. " Charge yield for Co-60 and 10keV X-ray irradiation" ,IEEE Trans.Nucl. Sci., **38**,1187, 1991
J.R.Schwank et al "Radiation effects in MOS oxides", IEEE Trans.Nucl.Sci., NS-55, 1833, 2008
F-Y.Su et al., IEEE Trans.on Nucl.Sci., 2022 (in press) DOI : 101109/TNS.2022.3153697

CENTRE FOR MEDICAL RADIATION PHYSICS

UNIVERSITY OF WOLLONGONG AUSTRALIA

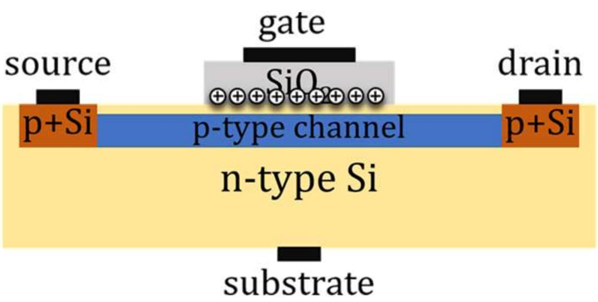
RadFET sensor for TID monitoring

Threshold voltage shift:

1. ΔV_{th} may be monitored *during* or *after* irradiation;

2. Bias on the gate during irradiation inhibits recombination of pairs; MOSFET response is linear with absorbed dose;

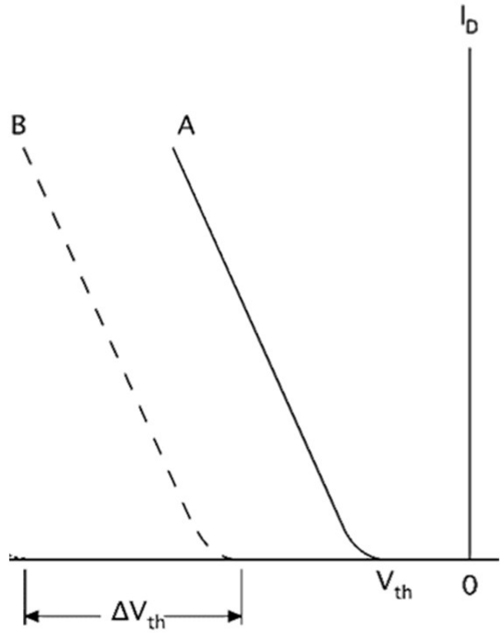
3. MOSFET sensitivity defined as:

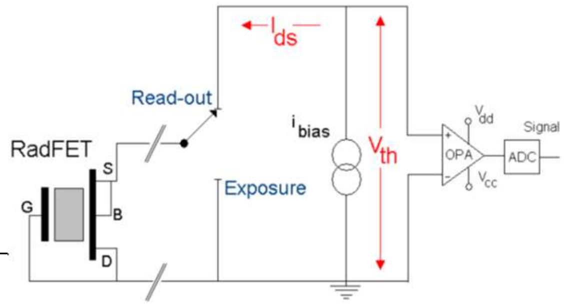


$$\Delta V_{th} \approx -\frac{qN_{ox}}{C_{ox}}$$

$$S \stackrel{\text{def}}{=} \frac{\Delta V_{th}}{D} \approx k_1 t_{ox}^2 f_E$$

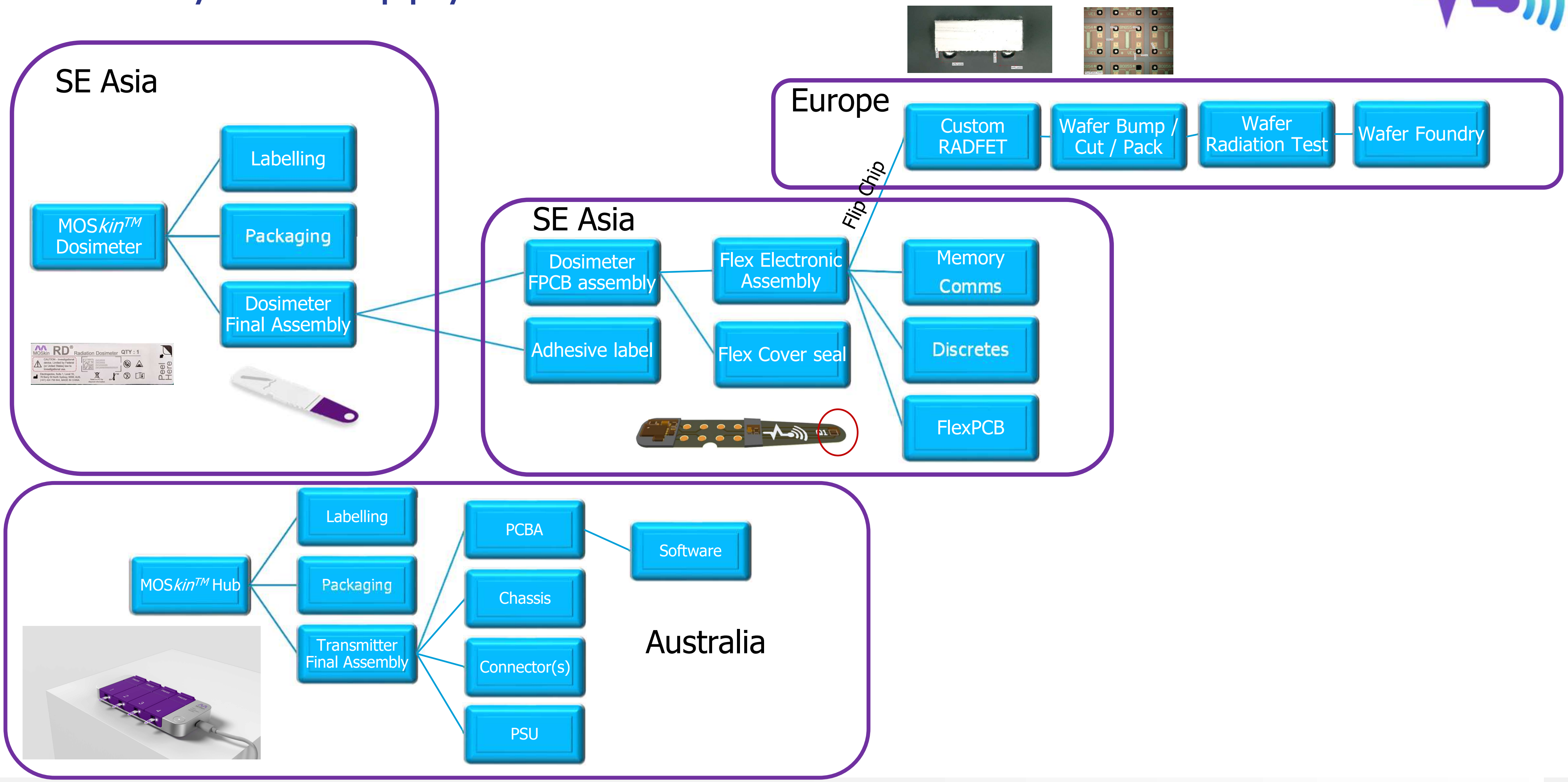
$$k_1 = 39 \frac{\text{mV}}{\text{cGy}\ \mu\text{m}^2}$$



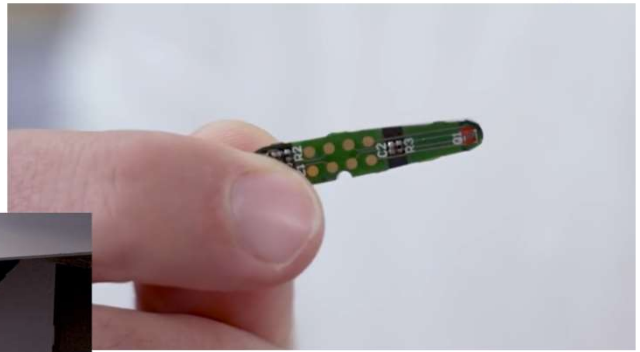


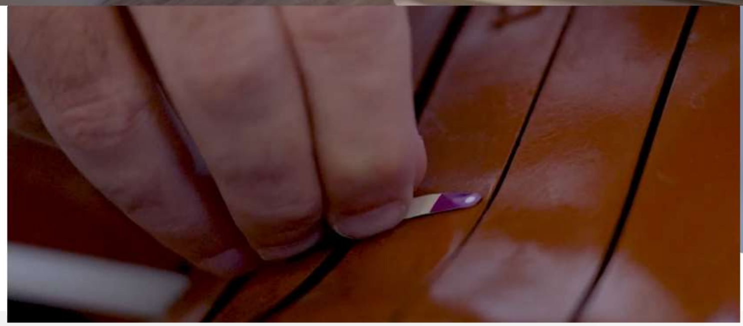
Taking into account for SiO_2 :
8.1×10^{12} e-h pairs/cm^3 cGy(Si),
i.e. no e-h recombination.

MOSkin™ System Supply Chain



MOSkin™ Testing





MOSkin™ benefits

Simple, fast, accurate dosimetry

- Set up in minutes by nurses or lab technicians. No need for additional specialist staff
- Instant results to support clinicians
- Accurate measurement of all radiation tissue depths including skin dose at Water Equivalent Depth (WED) of 0.07mm
- Wireless data transfer for real-time or passive mode
- Radio-translucent with no effect on radiation fields or visualisation
- Low unit cost , multi or single use – disposable

Substantially simplifies the entire clinical pathway, at a faction of the time and cost, with higher accuracy.

- **Leads to improved Linac patient throughput**
- **Leads to improved patient safety & convenience**
- **ELL dosimeters are single use, requiring no disinfection**
- **Lower skill level staff are required to use and operate**
- **ELL dosimeter accuracy is higher than existing products**
- **Overall costs per use are substantially lower**
- **Results are delivered @ Linac, not laboratory hours later**
- **Leads to lower hospital labour and facility costs**

Meeting clinical needs

Can be placed in more locations, offering **flexibility** in measurement of tumour and skin and surrounding tissue dose.

In Linac Beam Applications

- On skin to confirm skin is receiving sufficient dose, especially in head & neck cancers
- On skin to confirm skin not receiving unacceptably high dose in head, neck and breast cancers
- On skin with a build-up hemisphere to check right dose at maximum Linac power, for all cancers
- At multiple skin locations during Total Body Irradiation / Total Skin Electron Therapy
- Placed intracavity (e.g.. nose) to confirm dose

Out of Linac Beam Applications

- On eyelid with build-up to check eye lens not receiving unacceptably high dose during radiotherapy of head, neck, scalp & facial lesions
- Close to sensitive devices such as pacemaker/ implantable defibrillator to confirm device not receiving unacceptably high dose.

Patient benefits

✓ **Reduced risk of overdosing** (skin burns, increased risk of secondary cancers)

✓ **Reduced risk of under dosing** (inadequate treatment and potential for recurrence).

Multiple Revenue Models reduce market risk

MO*Skin*™ Dosimeters

- Consumable
- 3 per patient on one session(fraction)

- Growth - Increase fractions
- Growth - Increase % patients

MO*Skin*™ Hubs

- Capital Equipment
- 1 per LINAC

- Provide early revenue
- High margins

Diverse business and growth models

MO*Skin*™ Software

- Annual license
- 1 per LINAC

- Annuity revenue stream
- Growth – Add functionality

MO*Skin*™ Buildups

- Reusable
- 1 set per LINAC

- Access more use cases

Platform Technology – collaboration with CMRP

Application across multiple medical radiation measurement applications

Direct Radiation Therapy use in Cancer and Interventional C-Beam treatments

Dosage QA & Patient Efficacy

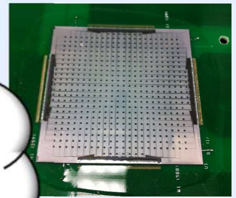
Disposable low cost, high accuracy General X-ray and CT Scan Dosage QA tools

Radiation Dose M'ment QA

Core IP embodied in a MOSFET and packaging technology that expresses exact measurement from radiation beam pass through.

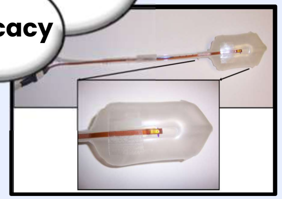
Multi-sensor detector for underbody interventional diagnostics and for exit radiation doses during radiotherapy for cancer

Dosage QA integrated to Linac Table



An 'in-balloon' single sensor to monitor radiation doses to internal organs during treatments such as prostate cancer

Dosage QA & Patient Efficacy



Development Partners

CENTRE FOR MEDICAL RADIATION PHYSICS

UNIVERSITY OF WOLLONGONG AUSTRALIA

The Centre for Medical Radiation Physics is a research team within the School of Physics, University of Wollongong. Dedicated towards the development of semiconductor detectors and dosimeters for clinical applications in radiation protection, radiation oncology and nuclear medicine as well as high energy physics applications.

NSW GOVERNMENT | Health South Eastern Sydney Local Health District

St George Hospital Cancer Care Centre
Radiation Oncology / Medical Physics

Treatment planning and delivery of advanced radiotherapy including

Intensity Modulated Radiation Therapy
Stereotactic Body Radiation Therapy
Stereotactic Radiosurgery
Volumetric Modulated Radiation Therapy
Brachytherapy

GENESYS ELECTRONICS DESIGN

Provides an ISO 13485:2016 certified electronic product and software development service from initial concept through to volume production.
Industry-wide reputation for delivering high quality, state-of-the-art solutions that are commercially ready.

D + I
Design + Industry

ISO 13485:2016 certified industrial design and product development consultancy, with over 50 industrial designers and mechanical engineers across Australia.

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AUSTRALIAN TECHNOLOGIES COMPETITION WINNER 2020

MOS*kin*™

Patented MOS*kin*™ is the simple, fast, accurate answer for *in-vivo* radiation dosimetry

Thank You