HASPIDE – WP3
Device Simulations

Status Activities

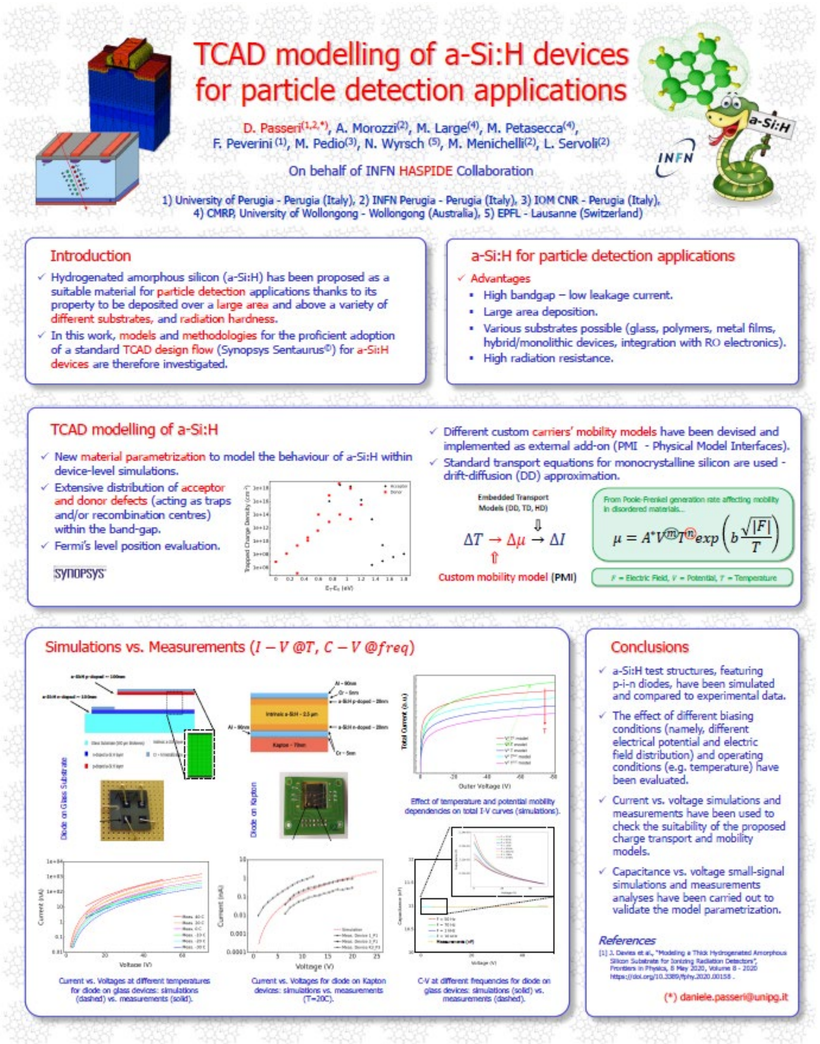
WP3: Device simulation

- ***Responsible:*** **Passeri Daniele**
- ***Working group: (PG, LNS, UOW)***

Name	Position	FTE-WP3
Daniele Passeri	Professore Associato (PG)	0.2
Francesco Moscatelli	Ricercatore (PG)	0.1
Arianna Morozzi	Tecnologo (PG)	0.25
Tommaso Croci	Assegnista (PG)	0.1
Marco Petasecca	Associate Professor (UOW)	
Matthew Large	PhD student (UOW)	
	TOTAL	0.65

14/06/23

Poster presentation at E-MRS 2023 Spring Symposium.



European Materials Research Society

- ✓ Huge congress (21 symposiums/parallel sessions!).
- ✓ M - Materials engineering for advanced semiconductor devices (more than 250 submission -> accepted 70 oral, 80 poster)
- ✓ Plenty of materials -> … no additional evidence of a-Si:H
- ✓ Few interactions – traps characterization.

Full paper in preparation / submission

TCAD modelling of a-Si:H devices for particle detection applications

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ARTICLE INFO

Keywords:
TCAD
Amorphous Silicon
Particle Detectors

ABSTRACT

Hydrogenated amorphous silicon (a-Si:H) has been proposed as a suitable material for particle detection applications thanks to its property to be deposited over a large area and above a variety of different substrates, including flexible materials. Moreover, the low cost and intrinsic radiation tolerance made this material appealing in applications where high fluences are expected, e.g. in high energy physics experiments. In order to optimize the device geometry and to evaluate its electrical behaviour in different operating conditions, a suitable Technology CAD (TCAD) design methodology can be applied. In this work, carried out in the framework of the HASPIDE INFN project, we propose an innovative approach to the study of charge transport within the material, using the state-of-the-art Synopsys Advanced TCAD Suite.

1. Introduction

2. TCAD modelling of a-Si:H

Technological CAD tools are routinely adopted within the design flow of silicon detectors for particle detection, given the availability of material models (monocrystalline Silison) and method (e.g. carriers' mobility,

Given the large variance in reported material properties for a-Si:H, there is at present no established commercial model of the material available to truly mimic the electrical and charge collection behavior of the unique material within the context of ionizing radiation detection applications. The vast majority of simulation based studies dealing with a-Si:H are primarily concerned with thin film devices (i.e., nm thickness range) for photovoltaic applications

The Sentaurus TCAD simulation tool was developed primarily for design and fabrication optimization of semiconductor electronic devices. Given that a-Si:H is not available within the standard material libraries, SYNOPSYS©users interested in simulating a-Si:H based devices are forced to develop their own material models to mimic the material behavior in the regime of interest.

A key focus point in this study is concerned with appropriately modeling the various deep level defects within the a-Si:H band-gap that can act as recombination centers and/or trap states.

Defect density or concentration of conduction and valence band tail states and Gaussian states within the a-Si:H material.

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- ✓ Materials Science in Semiconductor Processing (IF=4.64) Special Issue
- ✓ Deadline 30/06
- ✓ OpenAcces…

WP3 TCAD Simulation Outlines

- Traps description [1] -> Introduction rate / effectiveness.
- Warning! Band Gap description: Ec + vs. Ev - …
- Fermi's level position
- New bunch of fresh measurements
  - Effect of material activation (storage conditions…)
- Mobility model / mapping
- Devising of the model/strategy as reference (see paper in preparation) for further analysis (e.g. time varying) and optimization (charge collection, radiation damage effects)

[1] Nawaz M. Design analysis of a-Si/c-Si HIT solar cells. Adv Sci Technol. (2010) 74:131–6. doi: 10.4028/www.scientific.net/AST.74.131

WP3 Financial Request

- TCAD Software Licenses / WorkStation add-on (storage).
- Publication

			Year 1	Year 2	Year 3
Software / Licenses	PG	Synopsys Advanced TCAD Maintenance and Licenses	2 k€	2 k€	2 k€
	LNS				
	Wollongong				
Consumables	PG		2 k€	2 k€	2 k€
	LNS				
	Wollongong				
Equipment	PG	1 WorkStation (80 core, 256 GB RAM)	8 k€	3 k€ (1)	
	LNS				
	Wollongong				
Man Power	PG	1Y AR	25 k€		
	LNS				
	Wollongong				

- Charge Transport and Carriers Mobility Models
- An extensive acvitity has been devoted to the modeling of the charge transport within the a-Si:H, relying on standard transport equations for monocrystlline silicon - drift-diffusion (DD) approximation and using a custom defined charge mobility, looking at the current-voltage responses at different temperatures.

Embedded Transport Models
(DD, TD, HD)

F = Electric Field
V = Potential
T = Temperature

$$\Delta T \rightarrow \Delta \mu \rightarrow \Delta I$$

Custom mobility model
(PMI)

$$\mu = A^{*} V^{m} T^{n} exp\left(b \frac{\sqrt{|F| + F_{\min}}}{T} \right)$$

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